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JOURNAL

of

NYA
NGANYIKA
GANDA AND
NZIBAR

●

ol. XXV—No. 3

JANUARY
1960

●

Price: Sh. 4
nnual Subscription Sh. 15)
(German D.M.: 10.19)
(U.S. Dollars: $2.41)

World List abbreviation: *E. Afr. agric. J.*

IN THIS ISSUE:

NOTES ON KENYA AGRICULTURE—VIII

NOTES ON ANIMAL DISEASES

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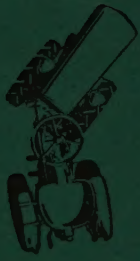

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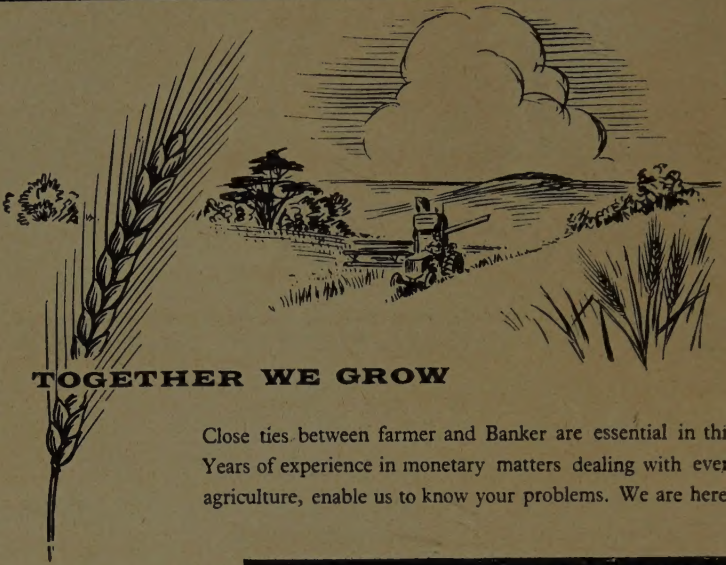

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THE
EAST AFRICAN AGRICULTURAL JOURNAL

Vol. XXV—No. 3 **JANUARY, 1960**

Printed and published by the Government Printer, Nairobi

Issued under the Authority of the East Africa High Commission and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue)

Editorial Board: Director of E.A. Agriculture and Forestry Research Organization; Director of E.A. Veterinary Research Organization; Directors of Agriculture, Kenya, Tanganyika, Uganda and Zanzibar; Directors of Veterinary Services, Kenya, Tanganyika and Uganda; Conservators of Forests, Kenya, Tanganyika and Uganda.

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EDITOR: J. GLOVER

E.A.A.F.R.O., P.O. BOX 21, KIKUYU, KENYA

Subscription Sh. 15 per volume (Sh. 4 single copy) including postage, payable to the Editor. Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.

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Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Double spacing should be used in typescript. Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the Journal, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

CONTENTS

	PAGE
Notes on Kenya Agriculture—VIII. Important Plant Diseases (*R. A. Robinson*)	131
Notes on Animal Diseases—III. Piroplasmosis and Anaplasmosis of Animals other than Cattle, and Trypanosomiasis of Domesticated Animals (*Dept. of Veterinary Services, Kenya*)	147
Notes on Animal Diseases—IV. Rinderpest (*Dept. of Veterinary Services, Kenya*)	153
High Altitude Ley Agronomy in Kenya—III. The Effects of Lime and Molybdenum, and some observations on the use of Legumes (*W. R. Birch*)	156
A Survey of the Use of Maize Stalk Borer Control Methods in East Africa (*P. T. Walker*)	165
The Culture of *Tilapia nigra* (Günther) in Ponds—III. The Early Growth of Males and Females at Comparable Stocking Rates, and the Length/Weight Relationship (*V. D. van Someren and P. J. Whitehead*)	169
Control of Infectious Diseases of Animals—I. (*Sir Thomas Dalling*)	174
Experiments on the Control of Stalk Borers on Sorghum in Uganda (*W. R. Ingram*)	184
Water-soluble Phosphorus in some Local Feeds and Faeces (*H. W. Dougall*)	188
Dosage Distribution upon Hand-sprayed Cotton (*D. Yeo*)	193
Coleoptera associated with Stored Products in Uganda (*J. C. Davies*)	199
Sharks of the Western Indian Ocean—II. *Triaenodon obesus* (Rüppell) (*J. F. G. Wheeler*)	202
Corrigendum	132
In Memoriam	152
Reviews and Reviews in Brief	168, 187, 204, 206

INDEX TO ADVERTISERS

	PAGE
Barclays Group of Banks	I
Dunlop Tyres	COVER PAGE 4
East African Breweries	IV
Gailey & Roberts Ltd.	COVER PAGE 2
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TEXT

If possible, the paper, including tables and illustrations, should not occupy more than five pages of print, i.e. 4,500 words, or 15 foolscap pages of double-spaced typing. Papers longer than this will probably be returned for revision, since they are almost certain to contain unnecessary detail.

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The number and size of tables must be cut to the absolute minimum, and a maximum of five compact tables should be sufficient for the presentation of experimental evidence. Only positive results should be included, since negative or inconclusive observations can be summarized in the text, and a reader who wishes further details can write to the author for them.

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The summary should not be longer than three per cent of the text, and it should be suitable for abstract journals.

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References in the text should either be by number or, preferably, by author's names and date, e.g. Smith *et al* 1954. Numbered references are listed at the end of the paper in numerical order, while author references are listed in alphabetical order. Abbreviations should conform to the World List of Scientific Periodicals: most abbreviations can be found in the reference section of previous papers in this journal.

The following papers give most useful advice on the presentation of technical papers:—

Price, W. C. (1954). Preparing manuscript for Phytopathology. *Phytopathology 44*, 675.

Moreau, R. E. (1947). On writing for this Journal. *E. Afr. agric. J. 12*, 171.

Riker, A. J. (1946). The preparation of manuscripts for Phytopathology. *Phytopathology 36*, 953.

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D. W. D.

THE EAST AFRICAN AGRICULTURAL JOURNAL

NOTES ON KENYA AGRICULTURE VIII: IMPORTANT PLANT DISEASES

By R. A. Robinson, Scott Agricultural Laboratories, Nairobi, Kenya

Approximately 300 diseases are described in these notes, but an additional 1,000 less important diseases have been recorded in Kenya and there are many non-parasitic conditions due to various adverse environmental factors and mineral deficiencies which are not described and which can easily be mistaken for true diseases. Symptoms which are not listed in the following Table of Diseases may thus be encountered fairly frequently but they can generally be assumed to be of minor importance.

DIAGNOSIS

As far as possible, only those symptoms which are diagnostic are described. Because faulty diagnosis can lead to the double wastage of worthless control measures and failure to control the disease, accurate diagnosis is very important. Ease of diagnosis of each disease is indicated as follows:—

(i) Diagnosis is easy; a plant pathologist need not be consulted.

(ii) Diagnosis is fairly easy; if in doubt, a plant pathologist should be consulted.

(iii) Accurate diagnosis is not easy; a plant pathologist should be consulted.

(iv) Accurate diagnosis is difficult; a plant pathologist must be consulted.

CONTROL

Control methods for each disease are designated only by numbers which refer to the following procedures:—

1. *International Quarantine.*—The disease in question does not occur in Kenya and plant importation regulations exist to prevent it being introduced. Permits to import plant material known to be free from disease can be obtained from the Director of Agriculture. If an outbreak of a new disease is suspected the Senior Plant Pathologist (P.O. Box 30028, Nairobi), should be informed *immediately* in order that attempts may be made to eradicate it completely.

2. *Regional Quarantine.*—Some regions of Kenya are free from certain soil-borne diseases and planting material of the crop in question should not be taken from one region to another. Consult a plant pathologist or the control methods in the Table of Diseases.

3. *Local Quarantine.*—If a farm or part of a farm is carrying a soil-borne disease such as Bacterial Wilt of Potatoes or Root Eelworm, do not move soil or diseased planting material from one part of the farm to another.

4. *Hygiene.*—Wash and/or sterilize pruning knives, secateurs, implements, tractor wheels, boots, hands, etc. Only important with highly infectious diseases (e.g. some virus diseases), very dangerous diseases (e.g. Bacterial Wilt of Potatoes) or outbreaks of new diseases.

5. *Soil Sterilization.*—Where special cases justify expensive control methods, soil sterilization by heat or chemicals can be employed. Covering the sterilized soil with polythene sheet will increase the efficacy of the sterilization.

6. *Rogueing.*—Destroy diseased plants within a crop to prevent the remaining healthy plants from becoming infected.

7. *Surgical Methods.*—Cut out and burn the diseased limb or branch of the affected plant.

8. *Destruction of Crop Residues.*—After harvest, destroy the crop residues.

9. *Rotation.*—Do not grow susceptible crops on the land in question until several years have elapsed.

10. *Insect Vector Control.*—Spray with an insecticide to control the insects (aphids, leafhoppers, etc.) which spread the disease.

11. *Use of Healthy Seed.*—Use only certified seed or seed otherwise known to have come from a disease-free parent crop.

12. *Use of Healthy Planting Material.*—Use only certified planting material of vegetatively reproduced crops (potatoes, sugar-cane, strawberries, etc.) or material otherwise known to have come from a disease-free parent crop.

13. *Green Manuring.*—Dig in a heavy dose of green manure.

14. *Armillaria Control.*—When clearing bush or forest, first ring bark all trees and large shrubs; clear the land when all these trees are dead. When the disease attacks crops, dig out the affected tree(s), remove any buried dead wood and leave the hole(s) open for about a year before replanting.

15. *Dithiocarbamate Fungicides.*—Spray at 7-12 day intervals with a dithiocarbamate fungicide (Zineb, Maneb, Thiram). These

fungicides are protective and should be applied before the disease appears.

16. *Captan.*—Spray with Captan at 10-14 day intervals.

17. *Copper Fungicides.*—Spray every 14 days with a copper fungicide (cuprous oxide, copper oxychloride, Bordeaux Mixture). These fungicides are protective and should be applied before the disease appears.

18. *Karathane.*—Spray or dust weekly with Karathane. Use Karathane in preference to sulphur fungicides, which are often ineffective in Kenya conditions.

19. *Organo-mercurial Fungicides.*—Dress or dip the seed or planting material with an organo-mercurial fungicide.

20. *Hot Water Treatment.*—Soak the seeds or planting material in water at the temperature and for the time stated. This is a delicate operation which must be carried out with great accuracy.

21. *Resistant Varieties.*—Use varieties known to be resistant or immune to the disease in question.

22. *Regular Water Supply.*—Mulch the crop and irrigate with frequent, small applications rather than infrequent, large applications.

23. *Soil Drainage.*—Improve the soil drainage.

24. *Wide Spacing.*—Space the plants widely within the crop.

25. *Close Spacing.*—Space the plants closely within the crop.

26. *Grafting.*—Ensure that susceptible scions are grafted on to resistant rootstocks and that graft incompatibilities do not occur.

27. *Early Sowing.*—The crop should be sown as early as possible.

28. *Early Harvesting.*—As the disease in question cannot be controlled, the crop should be cut, grazed or harvested before excessive loss occurs. Green manure crops should be ploughed in.

29. Remove the dead floral remains from the young banana tips.

30. Avoid damaging the trees when harvesting.

31. Soak the seed in cold water overnight and spread it out to dry in a very hot sun the following day. This method is only suitable in areas where very hot, sunny days can be relied upon.

Acknowledgments

This list of diseases was compiled mainly from the disease records at Scott Agricultural Laboratories, Nairobi. Although various mycologists have contributed to these records, they are largely the work of Dr. R. M. Nattrass. The standard works and scientific papers consulted were too numerous to be listed, but special mention can be made of "Revised List of Plant Diseases in Kenya Colony", by J. McDonald (*E. Afr. agric. J.*, 1936, pp. 1-6), "A List of Plant Diseases of Economic Importance in Tanganyika Territory", by G. B. Wallace and Maud M. Wallace (Mycological Papers Nos. 26 (1949) and 51 (1953), published by the Commonwealth Mycological Institute), and "Host List of the Parasitic Fungi of Uganda", by C. G. Hansford (*E. Afr. agric. J.*, 1943, p. 248).

CORRIGENDUM

Notes on Kenya Agriculture—VI. Grass Leys and Grassland Plants

p. 224 *Panicum colaratum should read P. coloratum.*

p. 224 *Lalipes senegalensis should read Latipes senegalensis.*

p. 226 "Direct planting without a grazing companion crop . . . etc." *should read* "Direct planting with a grazing companion crop . . . etc."

p. 227 ". . . especially where white clover is a part of the next sward." *should read* ". . . especially where white clover is a part of the mixed sward."

p. 228 "for the high rainfall seasons" *should read* "for the high rainfall areas".

p. 230 ". . . is recommended for seeding in some of the rainfall areas" *should read* ". . . is recommended for seeding in some of the low rainfall areas".

p. 233 *Pemmoseti stramineum should read Pennisetum stramineum.*

p. 233 *Snowdenia polystachia should read Snowdenia polystachya.*

p. 235 *Onobrychis vicifolia should read O. viciifolia.*

p. 235 *Trifolium ruepellianum should read T. rueppellianum.*

Table of Diseases

Crop Plant	Disease	Symptoms	Diagnosis	Control
Apple *Pyrus malus.* and Pear *Pyrus communis.*	Scab *Venturia inaequalis.* * *Venturia pirina.*	Black spots on fruit; fruit cracks; brown spots, later black, on leaves. Crop reduced.	ii	15 or 16
	Root Rot *Armillaria mellea.*	Layer of white fungus under the bark of roots and trunk base; tree dies.	iii	14
	Root Rot *Rosellinia necatrix.*	Thin sheet of black fungus on outside of bark of roots and trunk base. Tree dies.	iii	6
(Almond: *see* Peach)	Growth Cracks *Physiological.*	Large splits in fruit; secondary rots may develop.	i	22
(Apricot: *see* Peach)	Crown Gall *Bacterium tumifaciens.*	Hard, corky lumps on main roots and trunk base; growth and yields reduced.	ii	12
	*Silver Leaf *Stereum purpureum.*	Silvery appearance of leaves; tree usually dies; bracket fungi on dead wood.	iv	1
Asparagus *Asparagus officinalis.*	Rust *Puccinia asparagi.*	Orange-red pustules on aerial parts.	i	17
Bambara Groundnut *Voandzeia subterranea.*	Leaf Spot *Cercospora canescens.*	Roughly circular spots on leaves.	iii	17
Banana. *Musa sapientum.*	Panama Disease *Fusarium oxysporium.*	Plant wilts; violet-black discolouration of vascular ring of underground stem.	i	2, 3, 6 and 8
	Cigar-end Rot *Stachylidium theobromae.*	Tips of fruit resemble cigar ash.	i	29
	*Moko Disease *Pseudomonas solanacearum.*	Plant wilts; yellow-brown discolouration of vascular ring of underground stem which exudes bacteria when cut across.	ii	1
	*Bunchy Top *Virus.*	Plant dwarfed with characteristic grouping of leaves at its top.	iv	1
Barley *Hordeum sativum.*	Net Blotch *Helminthosporium teres.*	A network of brown lines on a lighter brown or yellow background which itself forms a leaf spot. Also causes a seedling blight.	iii	9 and 19
	Spot Blotch *Helminthosporium sativum*	Very similar to Net Blotch but forms a general speckling rather than a network of small brown spots. Also causes a seedling blight and root rot.	iii	9 and 19
	Leaf Stripe *Helminthosporium gramineum.*	Long, narrow, brown stripes on the leaves. Also causes a seedling blight.	ii	9 and 19
	Scald *Rhynchosporium secalis.*	Oval spots, up to one inch long, with grey centres and brown margins on leaves. Also causes a seedling blight.	ii	9 and 19
	Covered Smut *Ustilago hordei.*	Grains transformed into spore sacs which break to reveal a mass of black powder.	i	19
	Loose Smut *Ustilago nuda.*	Grains transformed into loose, exposed masses of black powder.	i	20 53°C. 10 mins.
	Take-all *Ophiobolus graminis.*	Empty heads which "ripen" before the rest of the crop. May also kill seedlings. Base of stem brown below sheath; soil clings to roots.	ii	9

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*This is an important disease which has not been recorded in Kenya.

Table of Diseases—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Barley—(*contd.*)	Stem Rust *Puccinia graminis.*	Orange-brown pustules on leaves, ears and stems; black pustules on stems are diagnostic.	i	21
	Yellow Rust *Puccinia glumarum.*	Yellowish pustules, mainly on leaves.	iii	21
	Brown Rust *Puccinia hordei.*	Brownish pustules, mainly on leaves.	iii	21
	Mildew *Erysiphe graminis.*	White, external mildew on leaves and stems. Leaves die.	i	none
	*Eyespot *Cercosporella herpotrichoides.*	Empty heads similar to Take-all. Crop lodges with the straw falling in all directions.	iv	1
Bean, Bonavist *Dolichos lablab.*	Scab *Elsinoe phaseoli.*	Raised, pale scabs on leaves, pods and stems.	iii	15 or 17
	Leaf Spot *Septoria lablabina.*	Brown spots on leaves.	iv	15 or 17
	*Rust *Uromyces dolicholi.*	Red-brown rust pustules on lower surfaces of leaves.	ii	15 or 17
Bean, Broad *Vicia faba.*	Chocolate Spot *Botrytis cinerea.*	(*a*) Non-aggressive stage; numerous chocolate-coloured spots on leaves (*b*) Aggressive stage: foliage totally destroyed.	ii	none
	Rust *Uromyces fabae.*	Reddish brown pustules on leaves.	i	none
Bean, French, etc. *Phaseolus vulgaris.*	Rust *Uromyces phaseolorum* and *Uromyces appendiculatus.*	Red-brown rust pustules, mainly on leaves; causes a characteristic green spot with yellow surround.	i	21 and 15 or 17
	Anthracnose *Colletotrichum lindemuthianum.*	Brown scabs on pods and stems, occasionally leaves.	iv	15 or 17
	Halo Blight *Pseudomonas medicaginis f. sp. phaseolicola.*	Small brown spot with wide "halo" of water-soaked tissue around, easily visible if held against the light.	ii	8, 9 and 19
	Scab *Ascochyta phaseolorum.*	Very similar to Anthracnose but occurs more frequently on the leaves.	iv	19
	Leaf Spot *Isariopsis griseola.*	Small brown leaf spots.	iv	21
	Mosaic *Virus.*	Symptoms differ greatly with variety. Generally a mottle of dark green and light green or yellow; leaves often brittle and plants dwarfed.	iii	6 and 11
	*Bacterial Wilt *Corynebacterium flaccumfaciens.*	Plants wilt and cut stems exude bacteria when squeezed.	iii	1
Bean, Soya *Glycine max.*	Scab *Synchytrium dolichi.*	Brown, raised scabs on stems and pods.	ii	21
	*Mildew *Peronospora manshurica.*	Leaf blight; large areas of leaf become necrotic.	iii	21
Beetroot *Beta vulgaris.*	Leaf Spot *Cercospora beticola.*	Small pale spots with red margins.	i	17
(Blackberry: *see* Raspberry)	Mildew *Peronospora schachtii.*	Leaf blight: relatively large areas of leaves become necrotic.	iii	17

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*This is an important disease which has not been recorded in Kenya.

TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
(Black Gram: *see* Gram)	Eelworm *Meloidogyne sp.*	Lumps on roots; may be as large as a golf ball.	i	9, 13
Brassicae including: Broccoli Brussels Sprouts Cabbage Cauliflower Kale Mustard Rape Turnip	Dark Leaf Spot *Alternaria brassicicola* and *Alternaria brassicae.*	Circular, brown, zonate spots on leaves. Black spots on cauliflower heads. *A. brassicicola* is serious on crops grown for seed.	ii	11
	Downy Mildew *Peronospora parasitica.*	Brown, necrosis on leaves and stems. Stem distortion.	ii	none
	White Rust *Cystopus candidus.*	Whitish pustules on leaves and stems. Skin of pustule breaks to reveal white powder.	ii	none
	Dry Rot, Canker *Phoma lingam.*	Damping-off; deep, brown lesions on stems.	iv	8 and 11
	Ring Spot *Mycosphaerella brassicicola.*	Large brown spots on the older leaves.	ii	11
	Black Rot *Xanthomonas campestris.*	Vascular bundles of either stems or leaves or both are black. Easily seen in leaf scar on stem when leaf is broken off.	ii	9 and 11
	*Yellows *Fusarium conglutinans.*	Yellowish, dwarfed growth; lower leaves fall off; discoloured vascular bundles.	iv	1
(Bulrush Millet: *see* Millet)	*Leaf Spot *Gloeosporium concentricum.*	Pale, circular spots on stems and leaves: spots are concentrically zoned with the white spore postules.	iii	1
	*Club Root *Plasmodiophora brassicae.*	Large galls on the roots.	i	1
(Cabbage: *see* Brassicae) (Cane: *see* Sugar)				
Cape Gooseberry *Physalis peruviana.*	Leaf Spot *Entyloma australe.*	Irregular leaf spots, mainly on older leaves.	i	17
Carnation *Dianthus caryophyllus.*	Rust *Uromyces dianthi.*	Red-brown pustules on stems and leaves.	ii	15
	Leaf Rot *Heteropatella valtellinensis.*	Brownish spots, later pale, on the leaves and stems; rapid spread can result in considerable damage.	iv	15 or 17
	Leaf Spot *Septoria dianthi.*	Light brown spots on leaves and stems.	iv	15 or 17
	Ring Spot *Heterosporium echinulatum.*	Circular brown spots with purple margin; occasionally affects stems and buds.	iv	15 or 17
	Eelworm *Meloidogyne sp.*	Galls on roots; can be very severe on this crop.	i	9 and 13
Carrot *Daucus carota.*	Leaf Spot *Alternaria dauci.*	Very small leaf spots; the whole crop can turn brown and appear blighted.	i	17
Cashew *Anacardium occidentale.*	Dieback *Mechanical.*	The very brittle wood of cashew often develops cracks due to high winds or heavy crops and secondary rots causing die-back of the twigs then develop.	i	none
Cassava *Manihot utilissima.*	Brown Streak *Virus.*	Sunken, brown streaks on otherwise green stems; stems become brittle. Old leaves develop a mottle.	ii	6 and 12

*This is an important disease which has not been recorded in Kenya.

Table of Diseases—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Cassava—(*contd.*)	Mosaic *Virus.*	Leaves reduced in size, twisted, misshapen, with bright yellow areas. Symptoms appear on *young* leaves c.f. "Brown Streak", above.	ii	6 and 12
	Leaf Spot *Cercospora henningsii.*	Leaf spots up to one centimetre in diameter, pale brown to grey with yellowish margin.	ii	8 and 9
Castor *Ricinus communis.*	Rust *Melampsorella ricini.*	Reddish pustules, generally on lower surface of the leaves.	i	none
(Cauliflower: *see* Brassicae)	Leaf Spot *Cercospora ricinella.*	Circular spots 0·5–1·0 cm. diameter, usually reddish brown with small white centre.	ii	8 and 9
Celery	Leaf Spot *Septoria apii-graveolentis.*	Small dark spots on leaves, crop often badly blighted.	i	9 and 11
Chillies *Capsicum spp.*	Mildew *Oidiopsis taurica.*	Yellow leaf spots with obscure margins.	ii	18
	Wilt *Fusarium spp.*	Plant wilts as if droughted even when soil is moist.	ii	9 and 23
	Leaf Spot *Cercospora unamunoi.*	Indistinct leaf spots, often diffuse; irregular yellowing.	iv	8 and 9
	Anthracnose *Colletotrichum capsici.*	Grey-brown spots on fruit which redden prematurely; fruit-stalks and twigs attacked; die-back of twigs and death of whole branches.	ii	15
	Virus Diseases	There are a number of important virus diseases of chillies but their diagnosis is very difficult and easily confused with genetic variations.	iv	none
Citrus including: Grapefruit Lemon Lime Orange Tangerine, etc.	Stem-Pitting *Virus.*	Small pits in wood seen when a small piece of bark is removed. Stems may be flattened: tree declines.	ii	12 and 26
	Scab *Elsinoe fawcetii.*	Raised, corky scabs on fruit; leaves misshapen with scabs mainly on lower surface.	i	17
	Leaf Spot; Storage Rot *Alternaria citrii.*	Worst as a fruit rot; firm black rot in navel oranges; watery-brown rot in lemons.	ii	28
	*Anthracnose; Wither-tip *Colletotrichum gloeosporioides.*	Young shoots die-back and brown patches appear on the leaves which soon fall. No fruit or only misshapen fruit. The worst strain(s) of this fungus do not occur in Kenya.	iii	1
	*Melanose *Diaporthe citrii.*	Stem-end rot and black spots on fruits; twigs and fruiting spurs may be killed.	iii	1
	*Bacterial Canker *Xanthomonas citrii.*	Brown, scabby spots with glossy dark margins, 1–10 mm. diameter on all green parts and maturing fruit.	iii	1
Clove *Eugenia caryophyllata.*	Sudden Death Disease *Valsa eugeniae.*	Tree dies in a relatively short time; internal yellow stain of wood.	ii	30
Clovers *Trifolium spp.*	Rust *Uromyces elegans.*	Small reddish leaf spots; red-orange pustules on lower leaf surfaces.	ii	28
	*Bacterial Wilt *Corynebacterium insidiosum.*	Plants stunted, eventually die. A difficult disease to diagnose.	iv	1

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Table of Diseases—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Clovers—(*contd.*)	*Crown Wart *Urophlyctis alfalfae.*	A large, warty gall develops around the stem base.	ii	1
Coconut *Cocos nucifera.*	*Bud Rot *Phytophthora palmivora.*	Wilting and blighting of terminal foliage followed by general die-back and death.	iii	1
	*Red Ring Cause unknown.	Ring of red vascular tissue in trunk. Leaves die and fall, tree may die.	iii	1
Coffee *Coffea spp.*	Coffee Berry Disease *Colletotrichum coffeanum.*	Scabs on berries which later turn black and valueless. Can also cause a ripe berry rot called "Brown Blight".	ii	Consult a Coffee Officer
	Rust *Hemileia vastatrix.*	Bright orange, powdery patches on lower surface of leaves.	i	Consult a Coffee Officer
	Stem Pitting or Bottling Cause unknown.	Bottle shape swelling of the stem and severe disorganization of the wood seen when stem is sawn across. Deep pits in sap wood. A new disease about which little is known.	iii	?
	Root Rot *Armillaria mellea.*	White fungus below bark of roots and stem base. Tree dies.	iii	14
	*Leaf Spot *Mycena citricola.*	Small brown leaf spots which leave "shot-holes". Premature leaf fall often leads to complete defoliation.	iii	1
Cotton *Gossypium hirsutum.*	Black Arm: Angular Leaf Spot *Xanthomonas malvacearum.*	Dark brown spots generally confined by the leaf veins. Twig blight; sunken, black stem lesions; boll drop, boll rot.	ii	8, 9, 19 and 21
	Leaf Spot *Ramularia areola.*	Angular leaf spots; fine white mould can be seen on lower surface.	ii	8 and 9
	Wilt *Fusarium spp.* and *Verticillium sp.*	Plants wilt in spite of moisture in soil.	ii	8 and 9
Cowpea *Vigna sinensis.*	Powdery Mildew *Erysiphe polygoni.*	Pale spots on leaves; may involve whole leaf: white, external mildew visible on lower surface.	ii	24
	Scab *Synchytrium dolichi.*	Raised, warty brown scabs on stems and pods.	iii	8, 9 and 11
	Leaf and Pod Spot *Ascochyta phaseolorum.*	Brown spots on leaves and pods.	iii	8, 9 and 11
	Leaf Spot *Cercospora canescens.*	Roughly circular to irregular spots, pale brown to grey centres with reddish margin; on leaves, stems, pods.	iii	8 and 9
Cucurbits *Cucumis spp.* Including: Cucumber Gourd Lemon Marrow Pumpkin, etc.	Powdery Mildew *Erysiphe cichoracearum.*	Pale spots on leaves; white mildew easily visible on lower surfaces of leaves.	i	18
	Downy Mildew *Pseudoperonospora cubensis.*	Yellowish spots, later necrotic, on leaves. May involve whole leaf.	ii	15
	Anthracnose *Colletotrichum lagenarium.*	Stem lesions; all parts above die and whole plant frequently killed.	iv	8, 9 and 17
	Stem Rot *Mycosphaerella citrullina.*	Very similar to anthracnose.	iv	17

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Table of Diseases—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Cucurbits—(*contd.*)	Mosaic *Virus.*	Symptoms variable; generally a marked mottling, mosaic, etc. on leaves. Can cause severe loss of fruit.	iii	4 and 6
	*Angular Leaf Spot *Pseudomonas lacrymans.*	Brown angular spots which exude drops of liquid containing the bacteria.	ii	1
	*Wilt *Erwinia tracheiphila.*	Leaf and general wilt: stem shrivels and bacteria exude when it is cut across.	ii	1
Dahlia *Dahlia spp.*	Leaf Spot *Entyloma dahliae.*	Circular, brown, necrotic spots on leaves.	i	8, 9 and 17
Date *Phoenix dactylifera.*	"Rust" *Graphiola phoenicis.*	Greyish-white pustules on lower surfaces of leaves.	i	none
(Finger Millet: *see* Millet) (Flax: *see* Linseed) (French Bean: *see* Bean) (Garden Pea: *see* Pea)				
Gladiolus *Gladiolus spp.*	Rust *Uromyces gladioli.*	Reddish pustules on leaves; easily confused with Botrytis spot.	ii	17
(Golden Millet: *see* Millet) (Gooseberry: *see* Cape) (Gourd: *see* Cucurbits)	Leaf Spot, Corm Rot *Botrytis gladiolorum.*	Small red spots on leaves, severe corm and stem rots.	ii	8, 9 and 19
Grams; Green, Black, etc. *Phaseolus radiatus* and *P. mungo.*	Anthracnose *Elsinoe phaseoli.*	Whitish, raised scabs on stems and pods. Irregular leaf spot.	ii	8, 9 and 11
(Green Pea: *see* Pea)	Powdery Mildew *Erysiphe polygoni.*	Easily visible, white, external mildew on lower surfaces of leaves.	i	18
	Scab *Ascochyta phaseolorum.*	Brown scabs on leaves, stems and fruit.	iii	8, 9 and 11
	Mosaic *Virus.*	Yellow and green mottling of leaves.	ii	6
Grape Vine *Vitis vinifera.*	Powdery Mildew *Uncinula necator.*	Easily visible, white, external mildew. Causes serious damage to fruit.	i	18
	Downy Mildew *Plasmopora viticola.*	Large brown patches on leaves. Resembles potato blight.	ii	17
(Grapefruit: *see* Citrus) (Grenadilla: *see* Passion Fruit)				
Groundnut *Arachis hypogea.*	Wilt *Various fungi.*	Plant shows drought symptoms although no drought exists.	iv	8 and 9
	Rosette *Virus.*	Leaves and plant dwarfed to form a small, tightly compacted plant.	ii	25
(Bambara Groundnut: *see* Bambara)	Leaf Spot *Cercospora personata.*	Dark brown, circular leaf spots. Can cause serious defoliation.	i	21
(Jack Bean: *see* Bean) (Kale: *see* Brassicae)				
Kapok *Eriodendron anfractuosum.* Kale: *see* Brassicae)	No important diseases.			

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TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Kenaf *Hibiscus cannabinus.*	Rust *Aecidium garkeanum.*	Reddish orange pustules on leaves.	i	none
	Stem Rot *Sclerotinia sclerotiorum.*	Plant wilts and dies: irregular black fungal bodies inside stem, mostly near ground level.	ii	3, 8 and 9
(Lima Bean: *see* Bean) (Lime: *see* Citrus) (Lemon: *see* Citrus)	Eelworm *Meloidogyne sp.*	Small nodules or galls on roots.	ii	8 and 9
Lettuce *Lactuca sativa.*	Leaf Spot *Septoria lactucae.*	Brownish leaf spot with irregular outline.	ii	8 and 9
	Stem Rot *Sclerotinia sclerotiorum.*	Plant wilts and dies; irregular black fungal bodies in the rotting tissues.	ii	3, 8 and 9
	Marginal Leaf Spot *Pseudomonas marginalis.*	Narrow, blackish lesions along leaf margins.	iv	3, 8 and 9
	*Downy Mildew *Bremia lactucae.*	Leaves yellowish, sometimes brown: may wilt.	iv	1
Linseed *Linum usitatissimum.*	Pasmo Disease *Sphaerella linorum.*	Brown lesions on leaves, stem and bolls. May cause severe defoliation at flowering time.	iii	9 and 11
(Loganberry: *see* Raspberry)	Rust *Melampsora lini.*	Orange pustules on leaves, stems and bolls, later turn black. Black-brown areas on stems called "firing".	iii	21
	Leaf Spot *Alternaria linicola.*	Seedlings killed.	iv	9
Lucerne *Medicago sativa.*	Leaf Spot *Pseudopeziza medicaginis.*	Small, reddish *spots* on leaves; they are not pustules c.f. Rust below.	ii	28
	Downy Mildew *Peronospora trifoliorum.*	Leaves turn brown and necrotic. Entire leaflets are generally affected.	iii	28
	Rust *Uromyces striatus.*	Small reddish *pustules* on leaves. Easily confused with "Leaf Spot".	ii	28
	Burn *Pseudoplea trifolii.*	Leaves appear to have been burnt.	iv	28
	Root Rot *Rosellinia necatrix.*	Patches within the crop wilt and die out completely.	iii	9
	*Crown Wart *Urophlyctis alfalfae.*	Large, irregular galls on the stems at soil level.	ii	1
	*Wilt *Corynebacterium insidiosum.*	Shoots short and bunchy: removal of cortex reveals discoloured wood: plants eventually wilt and die.	iv	1
Lupins *Lupinus spp.*	Rust *Uromyces renovatus.*	Reddish-orange pustules on leaves.	ii	28
	Wilt *Fusarium spp.*	Plants wilt although drought conditions are absent.	ii	8 and 9
Maize *Zea Mays.*	Trans Nzoia Disease *Climatic.*	One or more of the upper nodes rot with a brown internal discolouration: trapped water can be found in the sheath. Stem and leaves above affected node wilt and die.	iii	21
	Rust *Puccinia sorghi*	Reddish pustules on leaves. Difficult to distinguish from Polysora rust. Occurs at all altitudes.	iii	none

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TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
MAIZE—(*contd.*)	POLYSORA RUST *Puccinia polysora.*	Pustules paler, smaller and more numerous than *P. sorghi.* Occurs only below 4,000 ft.	iii	27
	HEAD SMUT *Sphacelotheca reiliana.*	Male and female inflorescences become black and sooty.	i	6 and 9
	WHITE BLIGHT *Helminthosporium turcicum.*	Large, pale brown, necrotic blotches on leaves.	ii	21
	PINK EAR ROT *Fusarium graminearum.*	Cobs rot with a dry rot and pink discolouration.	iii	8, 9 and 11
	RED SPOT *Physoderma maydis.*	Dark red, translucent spots on leaf mid-ribs, near stem end.	iv	2, 8 and 9
	DOWNY MILDEW *Sclerospora sorghi.*	Long, whitish lines on leaves: the disease is confined by the veins and spreads up and down the leaf only.	iv	8 and 9
	DRY ROT *Diplodia zeae.*	Stalks and cobs affected with dry rot. May cause a seedling blight. There may be a brown but not a pink discolouration of the cobs.	iv	8, 9 and 11
	STREAK *Virus.*	A delicate mottle of bright yellow and bright green all over the leaves.	ii	6
	*GALL SMUT *Ustilago maydis.*	Green, soft galls on all aerial parts; later burst to reveal mass of smut spores.	ii	1
	*BACTERIAL WILT *Xanthomonas stewartii.*	Plants dwarfed and wilted: bright yellow slime exudes from stem when cut across.	ii	1
MANGO *Mangifera indica.*	ANTHRACNOSE *Colletotrichum gloeosporioides.*	Black spots on fruit: all tender parts of tree attacked; can cause loss of leaves, flowers and fruit. A serious storage rot.	ii	16 or 17
	POWDERY MILDEW *Oidium mangiferae.*	White, easily visible external mildew; mainly on flowers. Causes loss of flowers and subsequent crop in higher altitudes.	i	18
(MARROW, MELON: *see* CUCURBITS.)	BLACK SPOT *Bacterium mangiferae.*	Black, spots on fruit, leaves and twigs. A serious disease at present confined to Nyanza Province.	iv	2
	*SCAB *Elsinoe mangiferae.*	Can cause serious losses in nurseries as a seedling blight.	iv	1
	*BLIGHT *Physalospora persae.*	Blossom blight and brown rot of the fruit.	iv	1
MILLET, BULRUSH *Pennisetum typhoideum.*	SMUT *Tolyposporium penicillariae.*	Individual grains are enlarged and found to contain black smut spores.	i	9
MILLET, FINGER *Eleusine coracana*	NECK ROT *Fusarium sp.*	A dead area of stalk just below the head. Grains do not fill.	ii	8 and 9
	*LEAF BLIGHT *Helminthosporium nodulosum.*	Numerous, elongated leaf spots, first light brown, then dark brown; yields reduced.	iv	1
MILLET, GOLDEN *Panicum miliaceum.*	HONEY-DEW; ERGOT *Sphacelia sp.*	Heads are sticky, later develop superficial black growth of secondary fungi.	ii	8, 9 and 11
(MONKEY NUT: *see* GROUNDNUT)				

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Table of Diseases—(_Contd._)

Crop Plant	Disease	Symptoms	Diagnosis	Control
(Naartje: _see_ Citrus) (Nectarine: _see_ Peach)				
Napier Grass _Pennisetum purpureum._	White Spot _Beniowskia sphaeroidea._	White pustules on leaves. This disease looks serious but is, in fact, harmless.	i	none
Oats _Avena sativa._	Crown Rust _Puccinia coronata._	Orange-red pustules on leaves.	iv	none
	Stem Rust _Puccinia graminis._	Black pustules on leaves and stems. Also reddish pustules on leaves which are difficult to distinguish from Crown Rust.	iv	none
	Leaf Spot _Helminthosporium avenae._	Yellow leaf spots with brown ring in centre.	ii	9
	Loose Smut _Ustilago avenae._	Floral spikelets transformed into masses of black spores which may remain intact until threshing.	ii	19
Onion _Allium cepa._ Includes Garlic and Leek.	Leaf Disease _Alternaria porri._	Grey spots later becoming large and purplish on leaves and stems which may break at lesions.	iii	8 and 9
	Downy Mildew _Peronospora destructor._	Leaves blighted; become pale brown and necrotic.	iii	8, 9 and 17
	*Smut _Urocystis cepalae._	Long lines of black spores embedded in the leaves.	ii	1
(Orange: _see_ Citrus)	*Yellow Dwarf Virus _Virus._	Short yellow streaks on leaf bases: leaves fall over; flower stalks yellow and twisted.	iii	1
Passion Fruit _Passiflora edulis._	Woodiness _Virus._	Fruit small and hard; contain little juice. Leaves may be mottled and dwarfed.	ii	none
	Brown Spot _Alternaria passiflorae._	Brown spots on the leaves. May also affect young stems.	iii	8
	Leaf Spot _Septoria passiflorae_ and _Septoria fructigena._	Not easily distinguished from Brown Spot.	iii	8
	*Grease Spot _Pseudomonas passiflorae._	Dark green, greasy blotches on fruit which fall prematurely. Brown leaf spots with yellow halo.	iv	1
Pawpaw _Carica papaya._	Black Rot _Ascochyta caricae._	Large, blackish, sunken areas on fruit.	iii	8
	Mildew _Ovulariopsis papayae._	Brown, necrotic lesions on leaves.	ii	18, 24
Pea, Green or Garden _Pisum sativum._	Leaf and Pod Spot _Ascochyta pisi._	Circular, often sunken, brown spots on leaves, stem and pods.	iii	11
	Powdery Mildew _Erysiphe polygoni._	White, easily visible, external mildew on leaves, stems and pods.	i	18
	Downy Mildew _Peronospora viciae._	Yellow blotches on leaves; lower surface often carries whitish or pale mauve mildew. Pods often seedless.	iii	17
(Peanut: _see_ Groundnut)	*Bacterial Blight _Pseudomonas pisi._	Olive-green to brown spots, later necrotic, on all green parts.	iv	1
Pea, Pigeon	Wilt _Fusarium udum._	Plant wilts even though no drought exists. Wood at stem base discoloured.	iii	8 and 9

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Table of Diseases—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Peach and Nectarine *Prumus persica.* Apricot *Prumus armeniaca* Plum *Prumus domestica.* and Almond *Prumus amygdalus.*	Rust *Tranzschelia pruni-spinosa.*	Orange-red pustules on leaves; often scabs on fruit.	ii	17
	Leaf Curl *Taphrina deformans.*	Leaves curled and often violently puckered; bright pink.	i	17
	Crown Gall *Bacterium tumefaciens.*	Hard, corky galls on main roots and trunk base. Tree may decline seriously or even die.	ii	12
	*Canker *Pseudomonas mors-prunorum.*	Branch die-back with long, shallow cankers below dying parts.	iv	1
Pear: *see* Apple				
Pineapple	Leaf Spot *Physiological.*	Brown spots, an inch or two long, with yellow margins on leaves.	ii	none
(Plum: *see* Peach)	Fruit Rot *Various fungi.*	Flesh of fruit soft and brown when cut open.	i	none
Potato *Solanum tuberosum.*	Bacterial Wilt *Pseudomonas solanacearum.*	Plants wilt even in moist soil: on squeezing a cut stem or tuber, white bacteria ooze out.	ii	2, 3, 8, 9 and 11
	Blight *Phytophthora infestans.*	Brown, necrotic areas on leaves.	ii	15 or 17
	Target Spot *Alternaria solani.*	Circular brown leaf spots with concentric markings.	ii	17
	Black Leg *Pectobacterium carotovorum.*	Plants wilt, stem reduced to rotting black mass.	iii	8, 9 and 11
	Black Dot *Colletotricum atramentarium.*	Premature yellowing and drying up of the plant: haulm often covered with minute black fungal bodies.	iv	8, 9 and 11
	Black Scurf *Corticium solani.*	"Lime encrustations" on surface of tubers and stems: upper leaves wilt: small aerial tubers formed in axils of leaves.	iii	8, 9 and 11
	Powdery Scab *Spongospora subterranea.*	Fairly deep, raised, loose scabs on surface of tubers.	iii	8, 9 and 11
	Virus X	Symptoms differ greatly with potato varieties ranging from symptomless to acute necrosis of growing point followed by death.	iv	6 and 11
	Leaf Drop Streak *Virus Y*	Brown leaf veins, later leaf stalks turn brown and brown streaks spread down the stem. Symptoms differ with potato varieties.	iv	6 and 11
	Leaf Roll *Virus.*	Leaves curl upwards but remain turgid and brittle. Symptoms differ somewhat with potato varieties.	iii	6 and 11
	Eelworm *Meloidogyne sp.*	Soft warty galls on tubers; size variable.	iii	8, 9 and 11
	*Golden Nematode *Heterodera rostochiensis.*	Plant dwarfed and yellowish, yields greatly reduced. Minute cysts visible on the roots.	iii	1
(Pumpkin: *see* Cucurbits)	*Bacterial Ring Rot *Corynebacterium sepidonicum.*	Similar to Bacterial Wilt but the vascular ring of the tuber is discoloured and may be separated by an open crack.	iv	1

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TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Pyrethrum *Chrysanthemum cinerariifolium.*	Bud Disease *Ramularia bellunensis.*	Buds die but stalk little affected. White mildew visible on the inner surface of the floral bracts.	iii	21
	False Bud Disease ? *Physiological.*	As for bud disease except that several inches of stalk also die and no mildew occurs on the bracts.	iii	21
	Root Eelworm *Meloidogyne sp.*	Numerous small galls on roots.	ii	8, 9 and 12
	Leaf Eelworm *Aphelenchoides ritzema-bosi.*	Brown blotches on the leaves, often confined by veins.	iv	Spray with Malathion
(Rape: *see* Brassicae)	Root and Crown Rots *Sclerotinia sclerotiorum* and *Sclerotinia minor.*	Plant dies; small black fungal bodies around base of crown.	iv	8, 9 and 23
Raspberry including: Blackberry Roysenberry Youngberry *Rubus spp.*	Leaf and Cane Spot *Septoria rubi.*	Greyish spots with purple border on leaves and stems.	iii	8 and 17
	Crown Gall *Bacterium tumefaciens.*	Hard, corky galls on roots and stem bases.	ii	8 and 9
	*Spur Blight *Didymella applanata.*	Purple blotches on stems, later turn grey. Leaves may have irregular brown spots.	iii	1
	*Cane Blight *Leptosphaeria coniothyrium.*	Stem base rots, causing wilt and death.	iv	1
	*Cane Spot, Anthracnose *Elsinoe veneta.*	Sunken white spots with a purple border on the canes.	iv	1
Rhodes Grass *Chloris gayana.*	Leaf Blight *Helminthosporium sp.*	Leaves turn dry and brown, generally from the tips backwards. Field may have droughted appearance when no drought exists.	iii	21
	Rust *Uromyces kenyensis.*	Orange red pustules on leaves.	ii	21
Rice *Oryza sativa.*	Blast *Piricularia oryzae.*	Long, oval leaf spots with grey centre and brown margin. Shrivelled areas on culm beneath sheath are diagnostic.	ii	8, 9, 19 and 21
	Arkansas Foot Rot *Ophiobolus oryzinus.*	Stem discoloured below water, no tillering, premature ripening. This disease is very similar to "Take-All" of wheat.	iii	8
	Stem Rot *Leptosphaeria salvinii.*	Ears are light; tendency to excessive tillering giving a green appearance to a crop which should be ripe.	iii	8
	*Sesame Leaf Spot *Helminthosporium oryzae.*	Dark or purple-brown spots, often with a pale centre on leaves, sheaths and glumes. Entire leaf may wither.	iii	1
	*Ufra Disease *Ditylenchus angustus.*	Ear may not emerge or may be sterile; generally dark brown. Seedlings often killed.	iv	1
Rose *Rosa spp.*	Powdery Mildew *Sphaerotheca pannosa.*	Conspicuous, external, white mildew on leaves and buds.	i	18
	Black Spot *Diplocarpon rosae.*	Black "Tar-Spots" on upper surface of leaves.	i	16

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TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
RYE GRASS *Lolium spp.*	RUST *Puccinia graminis* and *Puccinia coronata.*	Rusty pustules on leaves.	iii	28
SETARIA *Setaria spp.*	BUNT *Tilletia echinosperma.*	Seeds are enlarged and transformed into black fungal bodies.	ii	8, 9 and 11
SISAL *Agave sisalana.*	No important diseases.	Sisal is one of the few important Kenya crops which has no serious infectious diseases.		
SORGHUM *Sorghum vulgare.*	COVERED SMUT *Sphacelotheca sorghi.*	Diseased grains may appear either normal or enlarged and discoloured. They break easily to reveal a mass of black powdery spores.	i	19 or 31
	LOOSE SMUT *Sphacelotheca cruenta.*	The grains are transformed into loose, black masses of powdery spores and the entire head is black.	ii	6 and 9
	HEAD SMUT *Sphacelotheca reiliana.*	The entire head consists of a fairly hard mass of very coarse strands, all covered in black powdery spores. This fungus also attacks maize.	ii	6 and 9
	RUST *Puccinia purpurea.*	Rusty pustules on leaves. Entire crop may be discoloured purple-red at maturity.	ii	none
	DOWNY MILDEW *Sclerospora sorghi.*	Leaves blighted; under humid conditions, an external mildew can be seen on both surfaces of the leaves.	iii	8 and 9
(SOYA BEAN: *see* BEAN)				
STRAWBERRY *Fragaria vesca.*	LEAF SPOT *Mycosphaerella fragariae.*	Grey spots with purple margin on leaves.	ii	8, 9, 12 and 22
	FRUIT ROT, GREY MOULD *Botrytis cinerea.*	Soft rot of fruits. Under humid conditions, fruit covered with a grey mould.	iii	16
	ROOT ROTS *Various fungi.*	Leaves and plants die-back, usually killed; disease tends to occur in patches in the field.	iv	9 and 23
	VIRUS DISEASES *Generally mixtures of viruses.*	Mottling, crinkling, dwarfing etc. Stocks "decline" with reduced yields.	iv	6 and 12
SUDAN GRASS *Sorghum sudanense.*	MILDEW *Sclerospora sorghi.*	White mildew on leaves; easily visible under humid conditions.	ii	8 and 9
	RUST *Puccinia purpurea.*	Rusty pustules on leaves, often surrounded by purple discolouration depending on the variety.	ii	8
SUNFLOWER *Helianthus annuus.*	LEAF SPOT *Septoria helianthi.*	Circular, necrotic brown spots on leaves.	ii	8 and 9
	WHITE BLISTER *Cystopus tragopogonis.*	Blisters on leaves and stems with a mass of powdery white spores beneath a thin skin which later ruptures.	ii	8 and 9
	RUST *Puccinia helianthi.*	Reddish pustules on lower surface of leaves.	i	8
	ROOT AND STEM ROT *Sclerotinia spp.*	Plants wilt and die. Black fungal bodies can be found inside the stem and flower head.	iii	6, 8, 9 and 11

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*This is an important disease which has not been recorded in Kenya.

TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
Sugar Cane *Saccharum officinarum.*	Smut *Ustilago scitaminea.*	Central shoot is transformed into whip-like structure with hard woody core surrounded by a black mass of powdery spores.	i	6, 8, 9, 12, 21 and 20 52° C., 18 min.
	Leaf Spots *Various fungi.*	There are various sugar cane leaf spots which are difficult to distinguish.	iv	21
	Ratoon Stunting *Virus.*	A difficult disease to diagnose. Yields are reduced 10–15 per cent.	iv	12 and 20 52° C. 1½ hours
	Mosaic *Virus.*	Light green patches or blotches on the leaves, visible even when the young leaf unrolls.	iii	6, 12 and 21
	Streak *Virus.*	A fine, yellow-green mottle on the leaves.	iii	12
	*Gumming Disease *Xanthomonas vasculorum.*	A very serious disease; stripes on leaves. When stem cut across, the vasculars are red and exude a copious, sticky, yellow liquid.	ii	1
	*Wilt, Leaf Scald *Xanthomonas albilineans.*	Long, white stripes on young leaves; may turn red later. Plant wilts. No exudation of liquid c.f. Gumming Disease.	iii	1
(Tangerine: *see* Citrus)				
Tea *Thea sinensis.*	Root Rot *Armillaria mellea.*	Bush yellows and dies. Roots and crown have dense white mycelium below bark.	iii	14
	*Blister Blight *Exobasidium vexans.*	A very serious disease. Reddish galls or blisters on young leaves and shoots which then die.	iii	1
Tobacco *Nicotiana tabacum.*	White Mould *Erysiphe cichoracearum.*	Powdery white patches which amalgamate to form a white covering over the leaves which are then valueless.	i	24
	Frog-eye Spot *Cercospora nicotianae.*	Brown, necrotic spots, often with a pale centre on leaves.	iii	15
	Brown Spot *Alternaria longipes.*	Brown spots, often with yellow margin, on leaves; numerous, very small, dark spots on stems, midribs and flower stalks.	iii	6 and 8
	Wildfire *Pseudomonas tabaci.*	Red-brown, necrotic leaf spots with broad halo. Spots may coalesce to kill entire leaves. Under certain conditions the disease can be extremely damaging.	iv	6, 8 and 9
	*Anthracnose *Colletotrichum tabacum.*	Brown leaf spots which kill seedlings.	iv	1
	*Blue Mould *Peronospora tabacina.*	Dense, downy mildew on the lower surfaces of leaves. Mainly affects seedbeds; seedlings may be killed.	ii	1
	*Angular Leaf Spot *Pseudomonas angulata.*	Angular black spots on leaves, later brown with a central necrotic area which falls out.	iv	1
	*Kromnek *Tomato Spotted Wilt Virus.*	Symptoms differ with variety. Usually necrotic leaf spots or general necrosis.	iv	1

*This is an important disease which has not been recorded in Kenya.

TABLE OF DISEASES—(*Contd.*)

Crop Plant	Disease	Symptoms	Diagnosis	Control
TOMATO *Lycopersicum esculentum*	BLIGHT *Phytophthora infestans.*	Brown, necrotic areas on the leaves. The disease can be very damaging on the stem and the plant is killed.	ii	15 or 17
	TARGET SPOT *Alternaria solani.*	Circular brown leaf spots with concentric ring markings.	ii	17
	SEPTORIA LEAF SPOT *Septoria lycopersici.*	Not easily distinguished from Blight. The leaf spots tend to be smaller and darker.	iv	17
	BACTERIAL WILT *Pseudomonas solanacearum.*	Plant wilts even in moist soil. Squeezed cut stem exudes whitish, sticky mass of bacteria.	ii	2, 3, 5, 6, 8 and 9
	BLOSSOM-END ROT *Physiological.*	The end of the fruit furthest from stalk turns dark brown, sunken and rotten.	i	22
	*STEM ROT *Didymella lycopersici.*	Large sunken lesions on the stems. Plants generally die.	iii	1
	*BACTERIAL CANKER *Corynebacterium michiganense.*	Leaf veins turn brown, leaves wilt and die. Brown stripes on stem may crack open to reveal brown discoloured and ruptured internal tissues.	iv	1
	*SPOTTED WILT *Virus.*	Bronzing of leaves, either complete or in spots. Plant stunted sometimes killed outright by a general necrosis.	iv	1
(TURNIP: *see* BRASSICAE) (VEGETABLE MARROW: *see* CUCURBITS) (VINE: *see* GRAPE)				
WHEAT *Triticum vulgare.*	BLACK OR STEM RUST *Puccinia graminis.*	Orange-brown pustules on leaves, stems and ears; black pustules on stems. Grade and yields reduced.	i	21
	YELLOW RUST *Puccinia glumarum.*	Yellowish pustules on leaves and ears.	iii	21
	BROWN RUST *Puccinia triticina.*	Small orange pustules on leaves.	iii	21
	LEAF BLIGHT *Helminthosporium tritici-repentis.*	Pale brown flecks on leaves and sheaths which can be completely blighted.	ii	9 and 19
	TAKE-ALL OR WHITEHEADS *Ophiobolus graminis.*	Soil clings to roots and base of stem below sheath is discoloured. Ears whiten prematurely and are empty.	ii	9
	GLUME BLOTCH *Septoria spp.*	Dark flecks and blotches on the glumes and sheathes.	iii	8 and 9
	ROOT ROT *Helminthosporium sativum.*	Plants stunted, often wilted. At its worst on seedlings on under excessively wet conditions. Can cause a leaf spot on older plants.	iii	8, 9 and 19
	LOOSE SMUT *Ustilago tritici.*	An emerging ear consists of a loose, black mass of spores which soon blow away leaving the bare axis of the ear.	ii	20 53° C., 10 minutes
	BUNT *Tilletia foetida.*	Grain transformed into a blackish mass of spores which generally remains enclosed until threshing.	ii	19
	*FLAG SMUT *Urocystis tritici.*	Long black stripes on leaves, covered with a thin skin which ruptures to reveal powdery masses of black spores.	ii	1
	*EYESPOT *Cercosporella herpotrichoides.*	Lesions on straw just above soil level. Empty, prematurely ripe heads. Lodging in which the straws fall in all directions.	iv	1
(YOUNGBERRY: *see* RASPBERRY)				

*This is an important disease which has not been recorded in Kenya.

NOTES ON ANIMAL DISEASES

III—PIROPLASMOSIS AND ANAPLASMOSIS OF ANIMALS OTHER THAN CATTLE, AND TRYPANOSOMIASIS OF DOMESTICATED ANIMALS*

Compiled by the Department of Veterinary Services, Kenya Colony

PIROPLASMOSIS OF EQUINES (BILIARY FEVER)

Two species of piroplasms, both of which occur in Kenya, are known to occur in equines. They are *Babesia caballi* and *Nuttalia equi*.

Nuttalia equi

Microscopically, *Babesia caballi* closely resembles *Babesia bigeminum* of cattle in appearance, whereas *Nuttalia equi* is a smaller parasite, more akin to the species of the genus *Theileria*. The latter parasite is much more frequently encountered in Kenya.

Both parasites are tick-transmitted. Transmission of *Nuttalia equi* to susceptible horses by adult *Rhipicephalus evertsi*, that had fed during the larval and nymphal stages on carrier animals, was demonstrated by Theiler in 1905, and it is probable that other ticks may also be capable of transmitting infection. Experimental transmission of *Babesia caballi* by African species of ticks has not yet been effected.

Susceptible donkeys and mules may be infected with *Nuttalia equi* by the inoculation of blood from infected horses; but clinical infections in these animals are rarely observed.

Symptoms.—After experimental inoculation the incubation period in *Nuttalia equi* infection is from 7-9 days. After natural infection the incubation period may be as long as three weeks. In general the symptoms and post-mortem lesions produced by the two parasites are similar. However, with *Babesia caballi* a continuous temperature curve occurs, whereas with *Nuttalia equi* the fever is of the intermittent type.

The first visible sign of sickness is usually a pale yellow coloration of the mucous membranes of the eyes and mouth. Later, in severe cases, small haemorrhagic points occur in the third eyelid. The animal appears dull and shows lack of interest in its food, while its thirst is increased. During the early stages there is marked constipation, but later colicky pains and diarrhoea may be observed. The urine is usually increased in amount and yellow or reddish-brown in colour. Redwater occurs in rare cases; probably more frequently in severe *Babesia caballi* infection than in *Nuttalia equi* infection. Death may occur within four or five days of the onset of symptoms, or may be delayed for several weeks.

Post mortem lesions.—On post mortem examination the most obvious abnormality noticed is a general jaundice of the tissues. The blood is thin, pale and watery, the spleen swollen, and other lesions analogous to those observed in redwater in cattle are usually found.

Immunity.—Recovery from an attack of biliary fever leads to the development of a state of premunity in every way similar to that following recovery from redwater in cattle. The disease caused by *Nuttalia equi* is generally regarded as more severe than that caused by *Babesia caballi*.

Treatment.—Careful nursing and the control of constipation by the use of laxatives and enemata should form the foundation of treatment. Trypan blue and quinine were at one time used for treatment but have been superceded by specific drugs: quinuronium sulphate (under the trade names "Acaprin", "Acapron", "Babesan", "Diveronel", "Pirevan", "Pirocyl", "Piroparv" and "Piroquin"), and a different compound "Berenil" (Hoechst) have proved very effective when given by subcutaneous injection. Accurate dosage is essential and is based upon the estimated bodyweight of the animal. Each product is marketed at its own concentration and bears the recommended dosage with the packet. Accidental overdosage of a weakened animal may cause collapse. Phenamidine isethionate is also effective against the parasites but is seldom used because it tends to cause severe abscesses at the site of inoculation.

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* This is a revised version of "Notes on Animal Diseases—III" which was published in this Journal *12*, 220.

PIROPLASMOSIS OF PIGS

Infection of pigs by *Babesia trautmanni*, a parasite first described from pigs in the Kondoa-Irangi district of Tanganyika, has been observed but once in Kenya. The main symptoms are jaundice and redwater. The pathogenicity of the parasite appears to be low.

PIROPLASMOSIS OF DOGS (TICK FEVER)

Tick fever is most frequently seen in puppies, newly-imported dogs and highly bred dogs. Dogs bred in East Africa usually contract infection early in life and recovery leads to premunization. More frequently than in redwater, however, the blood of a recovered animal will fail to transmit infection to susceptible puppies. The causal parasite *Babesia canis*, is similar in appearance to *Babesia bigeminum* of cattle; but the infection of one blood cell with more than one pair of parasites, frequently seen in tick-fever smears, is most unusual in redwater. In Kenya the usual transmitting ticks are *Hoemaphysalis leachi* and *Rhipicephalus sanguineus*. In the case of the former species, only the adults are capable of causing infection. Infection is passed through the egg, but neither larvae nor nymphae transmit the parasite while feeding. In *Rhipicephalus sanguineus* infection is also hereditary. In this case, however, while the larvae of an infected female are non-infective, both nymphae and adults will transmit the disease if fed on a susceptible dog.

Symptoms.—After an incubation period of from 4-6 days in dogs inoculated with blood or of 10-21 days following the bite of an infective tick, the first indication of illness is a rise in temperature. Within a day or so dullness, loss of appetite and an increased desire to sleep are usually noticed. Anaemia is manifested by pallor of the eye membranes and the gums. Constipation may be present, the tongue is furred, breathing becomes increased in frequency and the pulse weak and fast. Later the appetite is completely lost and the dog becomes progressively weaker and weaker. Jaundice is often observed; but whilst the urine may be brownish-green in colour owing to the presence of bile pigments, true haemoglobinuria rarely, if ever, occurs. In acute cases death may occur three to ten days after the beginning of the temperature reaction.

Chronic cases in which the temperature reaction is slight or intermittent are not uncommon in puppies. In dogs so affected there is a progressively increasing anaemia. The animal is listless and its appetite capricious. Condition is rapidly lost. A percentage of these cases develop ascites, that is to say, fluid accumulates in the abdominal cavity and, even if removed, usually the fluid collects again rapidly. Such cases do not respond to treatment and almost invariably end fatally.

Treatment.—Several drugs are available for the specific treatment of tick fever: quinuronium sulphate (under the trade names listed under biliary fever of the horse), phenamidine isethionate and "Berenil" are all probably equally effective and are given subcutaneously. Dosage should be accurately assessed on a bodyweight basis, preferably by actually weighing the dog. More dilute strengths of quinuronium and phenamidine are available for use in small animals or the concentrated solutions may be suitably diluted. "Berenil" must be made up fresh from the crystalline drug. Accidental overdosage with any of these drugs may cause collapse a short time after dosage and full doses should not be repeated at frequent intervals. Deliberate underdosage is advisable in very severely affected animals; the smaller dose may be repeated 48 hours later. The patient should be given a warm bed and kept quiet for at least 48 hours after the injection. During this period the occasional administration of a little brandy and milk is often helpful, particularly in cases where the pulse is very fast and weak. During convalescence, which should be rigorously enforced, tonics such as Parrish's Food or acetarsol are of value. Exposure to cold and wet should be avoided.

Relapses may occur 7-10 days after treatment. When the patient is properly nursed specific treatment is usually unnecessary; but if the dog develops a high temperature and goes off his food specific treatment must be repeated.

PIROPLASMOSIS AND ANAPLASMOSIS OF SHEEP AND GOATS

Small piroplasms are occasionally seen in blood smears from sheep in Kenya. They do not appear to be of importance.

Anaplasmosis is also seen occasionally in sheep and goats. Apart from a rise in temperature the reaction is usually symptomless. The finding of anaplasmosis parasites in blood of animals showing illness and jaundice is therefore usually not significant; the possibility of other diseases such as leptospirosis and virus conditions should be investigated.

TRYPANOSOMIASIS

All species of domesticated mammals are susceptible to one or more forms of trypanosomiasis. This disease, usually called "fly", is caused by one of a number of species of trypanosome, unicullar animal parasites which infect the blood and tissues of the host. These parasites differ from piroplasms and anaplasms in that they occur free in the blood plasma and do not invade the cells.

All the pathogenic species of trypanosomes in East Africa are transmitted by the bites of flies. The parasites responsible for dourine, a disease of equines recorded from North and South Africa, as well as from other parts of the world, are transmitted from the mare to the stallion and vice versa at service.

The species of pathogenic trypanosomes that have been recorded from Kenya are *Trypanosoma brucei, T. vivax, T. congolense, T. evansi* and *T. simiae*. The first three of these are transmitted mainly by tsetse fly, although it has been shown that on occasion other biting flies (for example, the widely distributed species of *Stomoxys*) may be responsible for mechanical transmission, once infected cattle are introduced into a clean area. The disease caused by these species of trypanosomes, usually called "nagana", is, however, rarely of economic importance except in fly belts and adjacent areas. Tsetse flies may, however, be carried to the areas by trains or motor vehicles; although they cannot breed they may cause occasional cases of disease. The species of tsetse of major importance so far as animal trypanosomiasis is concerned in East Africa is *Glossina pallidipes*, but other species of the genus *Glossina* are potential transmitters of these parasites. *Trypanosoma evansi*, the cause of surra, is transmitted by tabanid flies and possibly by *Ornithodoros* ticks.

Fly belts in East Africa are rarely clearly demarcated areas. Under certain climatic conditions tsetse flies, in particular *Glossina pallidipes*, show a tendency to migrate from their habitual breeding grounds and to occupy temporarily new territory. This process is known as dispersal, and accounts for outbreaks of "fly" in areas adjacent to, but not usually considered as parts of, recognised fly belts. Sporadic cases of "fly" may be caused by tsetse that have been carried from their usual haunts by motor-cars, railway carriages or other vehicles, or that have followed herds of game on migration.

Surra in East Africa is mainly a disease of camels, and in Kenya is restricted to parts of the Northern Frontier Province and the coastal belt.

Whilst the train of symptoms produced by the different species of trypanosomes in East Africa is generally similar, the species vary in their pathogenicity for the different domesticated animals. It is important to note also that various strains of each species are recognised that differ amongst themselves in pathogenicity.

Trypanosoma congolense is probably the commonest species causing nagana in cattle. In addition, strains of this species are usually highly pathogenic for dogs. Sheep, goats and equines are somewhat less susceptible. As a parasite of cattle, *Trypanosoma vivax* is next in importance in Kenya. Sheep and goats may also be found infected, but horses are relatively insusceptible and dogs are resistant. *Trypanosoma brucei*, on the other hand, is highly pathogenic for horses, camels, dogs and pigs. Cattle, sheep and goats, although they react to the extent that after inoculation parasites may appear and multiply in their blood, show no marked symptoms of infection.

Trypanosoma evansi has a similar pathogenic range to *T. brucei*. Surra is essentially a disease of horses, camels and dogs, whereas in cattle a mild chronic form occurs, the majority of animals showing little or no outward evidence of infection.

In addition to the pathogenic species, a large trypanosome, *T. theileri*, is commonly encountered in cattle. This species which is in all probability transmitted by tabanid flies, is rarely of economic importance. Premunized animals may, however, relapse to infection when reacting to some other disease, such as rinderpest, thus increasing the severity of the reaction. Pigs may be infected with *T. simiae* or *T. brucei* both of which are rapidly fatal. *T. congolense* may infect pigs but is almost non-pathogenic.

Symptoms: *Cattle.*—In cattle infected with *Trypanosoma congolense* the first evidence of infection is a rise in temperature 5-10 days after exposure. In the case of work oxen visible evidence of infection may be present 5-7 days later; but in other cattle the disease often develops slowly and several weeks may elapse before untoward symptoms are noticed. Such symptoms are dullness, lack of appetite and lack of energy. The animal shows discomfort when the eyes are exposed to strong light, and there is some lachrymal discharge. Further symptoms gradually become evident. The animal falls off in condition, the eyes appear sunken, the coat becomes staring and in milch cows there is a reduction in yield. The lymph glands may be sufficiently swollen to be visible, as in East Coast fever, and diarrhoea may be observed. In the final stages the eye becomes opaque, the animal is extremely emaciated and very weak. A percentage of cattle show oedematous swellings of the throat, dewlap and belly.

The progress of the disease is always hastened by exposure to cold or rain, or by working or when the disease is complicated by a fluke infection.

Infection with *T. vivax* usually leads to a similar, but milder, infection in cattle. Housed cattle, if well fed, may show few definite symptoms, but symptoms may be noted in work oxen and in infected cattle moved to cold, wet districts.

T. vivax occasionally causes acute disease of cattle with sudden death. This form of the disease appears to be rather confined to certain districts. Deaths may occur within three weeks of infection and without premonitory symptoms. At post mortem haemorrhages are found in the musculature and on the surfaces of nearly all organs. The findings are indistinguishable from those of bovine petechial fever (ondiriitis) and the two diseases have often been confused. It is essential to take smears of blood and from the heart muscle as soon as possible after death in order to detect *T. vivax* parasites which rapidly disintegrate in the carcase.

Pure natural infections of cattle with *T. brucei* and *T. evansi* are rarely observed in East Africa. It may be pointed out, however, that it is not uncommon for an animal to be infected with more than one species of trypanosome.

Equines.—Following infection with *T. evansi* and *T. brucei*, the more pathogenic trypanosomes for horses, mules and donkeys, trypanosomes may be found in the blood in from 5-8 days. The temperature curve in these animals is usually irregular, showing peaks at varying periods. A tendency to avoid light and a water discharge from the eyes, muscular stiffness, dullness and depression are usually present, while oedematous swellings of the legs and abdomen may be noticed for varying periods. In the later stages loss of condition is progressively more marked, and the animal becomes very weak. Opacity of the eye is usually seen.

Milder symptoms are usually evinced when equines are infected with *T. congolense*, and the infection is not always fatal. As in the case of cattle infected with fly, however, work and exposure to inclement weather will frequently precipitate a more severe form of the disease. *T. vivax* is of little significance in equines.

Sheep and goats.—The smaller ruminants are on the whole relatively resistant to infection. Natural cases of *T. congolense* infection in sheep have been observed in the coastal region of Kenya and in parts of the Masai reserve, and infections with *T. brucei* and *T. vivax* have been recorded in Kenya and other countries. The symptoms shown are emaciation, oedematous swellings, running of the eyes and an irregular temperature reaction.

Pigs.—*T. simiae* multiplies rapidly in the blood of pigs and death occurs within a few days of a septicaemic type of disease. Infection with *T. brucei* is more chronic, but cerebral symptoms often occur as in human sleeping sickness.

Camels.—Surra in camels may run a "rapid" course, death occurring within a few months, or the infection may be more chronic, lasting several years. The animal loses its appetite and becomes easily tired. The eye is dull and paroxysms of fever occur at intervals. Oedema of the abdomen, sheath and pads is sometimes seen. In the more slowly developing cases emaciation is very marked, and paralysis may be observed before death. Such cases often terminate with a secondary pneumonia.

Dogs.—Dogs are highly susceptible to infection with *T. brucei*, *T. evansi* and *T. congolense*. The course of the disease is, however, as in other animals, chronic. There is a primary temperature reaction, followed by an irregular up and down curve. Lack of appetite and progressive wasting are noticed. Eye symptoms develop early, opacity of the anterior membrane of the eye being frequently seen. Oedematous swellings of the legs are particularly common in *T. brucei* infections. Jaundice may be present. In the later stages there is great weakness and apathy. Breathing appears difficult and the pulse becomes almost imperceptible.

Dogs are usually relatively resistant to *T. vivax* infection.

Post mortem lesions.—A definite diagnosis of trypanosomiasis can rarely be given from the appearance of the organs alone. The carcase is emaciated, anaemic and the subcutaneous tissues and the muscles are watery. The spleen may be enlarged, the lymph glands swollen and soft. The more striking lesions caused by acute *T. vivax* infection have been outlined previously.

Diagnosis.—Although tryanosomes may be numerous in the blood during the early stages, they become scanty as the disease progresses. In animals showing an irregular temperature curve, there is an increase in numbers during the period in which the temperature is elevated, and in some cases a further increase occurs in the blood shortly before death. When possible, therefore, both thick and thin smears for diagnosis should be made while the temperature is high. Wet smears are often a help in making a diagnosis. In a drop of blood placed on a slide and covered with a coverslip the motile parasites can often be detected under the lower power of the microscope much more readily than they can be found by searching a stained smear with an oil-immersion lens. Gland smears may reveal the presence of parasites when blood smears are negative, and are particularly useful in *T. vivax* infection.

Treatment.—The results of treatment are dependent on the species of animal, the infecting trypanosomes and the stage of the disease. The earlier treatment is given the better the results which may be expected. Results in cattle are usually good. *T. brucei* infection of dogs usually responds to treatment, but failures are often experienced with *T. congolense* infection. In horses, also, results with either *T. brucei* or *T. congolense* infections are often disappointing. Treatment of *T. evansi* infection of camels is effective. There is no certain cure for *T. simiae* infection of pigs.

A wide variety of drugs has been tested in recent years. For *T. brucei* and *T. evansi* infections, antrypol, the equivalent of Bayer 205 and Fourneau 309, is used. Antrycide is also effective against *T. evansi*. Antrypol should be given at weekly intervals to horses and dogs for four weeks.

For *T. congolense* and *T. vivax* infections antrycide methyl sulphate, "Berenil" or one of the phenanthridinium compounds should be used. A single injection is usually effective in the case of cattle. In very chronic cases, a repeat injection of the drug may be advisable after three weeks.

In the case of horses and dogs relapses are frequent and the effectiveness of treatment should always be checked by subsequent examination of blood smears.

The anaemia of trypanosomiasis only disappears very slowly and in horses and dogs the administration of haematinics, containing iron or arsenic, is to be recommended.

Trouble was experienced in some areas following the use of dimidium bromide, the first phenanthridinium compound to be widely used. Delayed toxicity was manifested by jaundice and photosensitization in some cases. Dimidium bromide is still used in many districts but is rapidly being superseded by homidium salts (sold under the trade names of "Ethidium" and "Novidium"). Homidium has been found to have a much wider safety margin, to be effective in smaller doses and no toxicity has so far been attributable to it.

Prophylaxis.—While considerable success has been obtained from the use of antrycide pro-salt, this method of control requires careful investigation and planning, to ascertain the threat to the cattle and to advise the most suitable dosage schedule. "Prothidium" has provided prophylactic cover for stock and other drugs are under test. The risk of producing drug resistant strains is so great that prophylaxis in this disease should always be discussed fully with the Department before it is attempted.

Control of trypanosomiasis.—Although in certain circumstances the destruction of game animals, that act as reservoirs of the parasites and provide the main food supply of the tsetse flies, has done much to eliminate trypanosomiasis, the main trend of modern experimental work is towards the discovery of cheap and efficient methods of eradicating the fly. A vast amount of work has been done on this subject, and it is impossible to deal with it here. Each fly area appears to present a distinct and individual problem, and methods of attack likely to be successful can only be devised after a detailed survey, by an entomologist who has specialized in this subject. Such methods of attack can even then be regarded as only experimental and more likely to lead to a reduction in the numbers of fly than to complete eradication.

A warning may not be out of place as to the dangers of attempting control without expert advice. As an example of the intricacy of the subject it may be mentioned that in certain areas regular grass burning, carried out under a definite plan, has led to a marked reduction in the number of fly, whereas, in other areas, the prohibition of grass burning has produced the same effect. Probably the only generally successful method of combating fly is the introduction of dense, compact agricultural development of the area. Unfortunately in many dry, infertile districts such development is not possible.

The game animals of Africa complicate the control of nagana. In fly belts, antelopes and other game harbour infection without showing symptoms, and hence act as reservoirs of infection. Similarly camels, and to a lesser extent cattle, act as reservoirs of infection of the parasite of surra.

Trypanosomiasis should always be regarded as a difficult, insidious disease and not readily banished by the simple use of a drug by the farmer. The problem should always be discussed with officers of the Department of Veterinary Services.

IN MEMORIAM

Alexander John Wiley

16*th January,* 1917, *to* 17*th September,* 1959

The sudden death of Alex Wiley on 17th September, 1959, came as a profound shock to his many friends and has left a gap in the ranks of East African parasitologists and naturalists which will be most difficult to fill.

Alex came to Kenya with his parents in 1929. After completing his education at St. Aidan's College, Grahamstown, he joined the Kenya Veterinary Department in 1936 and worked with Dr. E. A. Lewis. In 1945 he went to England to study at the Royal Veterinary College but was prevented by severe illness from completing these studies and returned to work with the Veterinary Department. Shortly afterwards he married Mary Pauline Tattersall, whom he had met when she was nursing at the London Hospital. He was appointed Zoologist (Entomology) in 1956, a post which he held until his death.

Although he was a quiet and unassuming man, Alex became well known as a veterinary parasitologist. He was especially interested in the tsetse flies and ticks of Kenya and in the role they play as transmitters of diseases of both animals and man. Much of our present knowledge of the distribution of the numerous species of ticks found in this country is based on his work although, unfortunately, he had actually published but little of this information. He worked on the problem of the blue tick's resistance to different dips and sprays, and for the last few years was responsible for the examination of specimens sent in by farmers for the diagnosis of helminth infestations in livestock. He was a very practical man and was always ready to give help and advice on these problems when it was requested. He was also interested in poisonous plants, many of which he grew in a demonstration garden which he established at Kabete.

Those of us who have had the pleasure and privilege of knowing Alex Wiley will retain warm memories of him through the years to come. We extend our deepest sympathy to his wife Mary, to his children and to his parents and sister.

J.B.W.

NOTES ON ANIMAL DISEASES

IV—RINDERPEST*

Compiled by the Department of Veterinary Services, Kabete, Kenya

Rinderpest is an acute contagious virus disease of ruminants and swine, characterized by diarrhoea, nasal and lachrymal discharge and by ulceration of the mucous membrane of the mouth.

Aetiology.—Rinderpest is caused by an ultra-visible and filtrable virus which become attached to the white cells of the blood and blood-forming organs.

Symptoms.—After an incubation period of from two to nine days the temperature rises sharply to 104° F. or more. The muzzle appears dry and the coat staring. The appetite is reduced, and after one or two days a little discharge is noticed at the eyes and nose. The eye becomes very susceptible to light and the mouth very congested. The temperature remains elevated for three days to a week, after which it falls to normal or below normal. At this time coughing may be noticed, diarrhoea is always present and an examination of the mouth will show pitted elevations of the lower surface of the tongue. By this time the animal has usually lost condition, the eyes are sunken and the flanks hollow. Grinding of the teeth and other symptoms of abdominal pain are evident and diarrhoea becomes more and more marked. Dysentery is frequently observed, and the animal becomes very weak and unable to rise. Death usually occurs 10 to 20 days after infection. Breakdowns to redwater and less frequently to coccidiosis may occur; pregnant animals that recover from the disease usually abort during the third week after infection.

Post-mortem Lesions.—In natural cases of the disease in adult animals the post-mortem lesions are usually characteristic. The mouth, pharynx, larynx and, in the female, the vagina are markedly inflamed and show patches upon which the epithelium has become lost or changed into a cheesy deposit. Although considerable areas may be raw, examination of the adjacent areas less severely affected shows that the lesions begin as numerous pinhead-sized ulcers. Larger areas are formed by the confluence of numbers of such ulcers.

The fourth stomach is usually intensely inflamed and several shallow irregular-shaped ulcers with haemorrhagic margins are almost constantly present. On the folds in the anterior portion the ulcers are usually very narrow and elongated. Nearer the junction with the intestines (the pylorus), the ulcers are more round or oval in shape and traces of yellowish-grey necrotic mucous membrane may still be adhering. Diffuse congestion, and sometimes free haemorrhage, is present in the small intestine. In the large intestine the caecum shows typically a network of broad bands of congestion and longitudinal lines of haemorrhages are constantly seen in the rectum. Diffuse patches of congestion and haemorrhage may be present throughout the large intestine.

The liver and spleen are usually somewhat swollen and engorged with blood. The kidneys are congested, particularly the medullary (inner) portion of the pyramids. The mucous membrane of the bladder often shows small haemorrhages and, of course, when a breakdown to redwater has occurred the urine is deep red in colour.

Mouth lesions, similar to those of rinderpest, occur in malignant catarrh and in diseases of the so-called "mucosal disease complex", for example, papular stomatitis. The principle distinguishing feature between rinderpest and malignant catarrh is the great enlargement of the lymph glands in the latter condition. Furthermore, it is generally confined to a small number of animals and shows only a limited tendency to spread. Diseases of the "mucosal complex" vary in the symptoms produced, but in all there is some abnormality of the alimentary tract on post-mortem examination. Animals may be affected in an acute or mild form but, generally speaking, most will recover after an illness lasting from one to three weeks. Calves and young animals are more commonly affected than adults. A similar picture is presented by mild (atypical) forms of rinderpest or by isolated outbreaks of rinderpest in partially immune animals. In these cases, diagnosis is not easy and specimens from affected animals (*see* later) should be sent to the laboratory for confirmation. In typical outbreaks, however, rinderpest is one of the easiest diseases to recognize.

Animals Susceptible.—All ruminants and pigs are susceptible to rinderpest, but the degree of susceptibility varies. Cattle and buffalo are highly susceptible, mortality in uncontrolled outbreaks of the disease often surpassing 90 per cent. In East Africa, sheep and goats are relatively resistant to strains occurring naturally, although these animals may be infected by the inoculation of virulent material, apart from a temperature reaction they show little evidence of infection. In French West Africa, however, there is a large breed of goats which reacts severely to inoculation. Pigs, on infection, behave similarly to sheep and goats. Camels are slightly more susceptible. Among wild species, buffalo, eland, kudu and warthog appear to be the most susceptible. Mortality in these species is heavy and they are of great importance in spreading the disease from farm to farm and from district to district. Giraffe, bushbuck and forest hog are only slightly less susceptible, but although other species of buck may contract the disease, mortality in them is unusual.

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* This is a revised version of "Notes on Animal Diseases—IV" which was published in this Journal *13*, 29.

Although herds of buffalo and other game are of great importance in the spread of rinderpest in East Africa, it is the considered opinion of those who have studied the question that game do not harbour rinderpest for long periods. Rinderpest spreads rapidly in buffalo herds, so that after a comparatively short time all the susceptible animals have either died or recovered to become immune.

Transmission.—Rinderpest is a contagious disease. The virus is present in all the discharges of sick animals, and healthy cattle contract infection through eating or drinking contaminated material. The virus is a relatively delicate virus, being rapidly destroyed outside the animal body by physical and chemical agents. Blood at room temperature loses its infectivity in a few days when kept under the most favourable conditions, and materials splashed with blood become harmless in three days even when stored near freezing point.

Confirmation of Diagnosis.—Nowadays the presence of rinderpest can often be confirmed at the laboratory within 24-48 hours of receipt of fresh, unpreserved lymph gland (preferably mesenteric) from affected animals. The test used is known as the agar-gel double diffusion technique.

Blood in sterile citrate solution must always accompany gland specimens from suspected outbreaks for transmission experiments. Equal quantities of blood and citrate mixed together should be despatched on ice with as little delay as possible. O.C.G. should not be used as rinderpest virus does not resist the action of this preservative.

Treatment.—There is no specific drug of value in the treatment of rinderpest. Hyperimmune serum in doses of 250-500 c.c. may be used for cattle that have been exposed to infection, but it is very doubtful if the inoculation of hyperimmune serum can modify the course of the disease when it is given after symptoms other than a rise in temperature have appeared. Bleeding a few hundred c.c. from the jugular vein appears to be beneficial when the temperature is high.

Preventive Inoculation.—Rinderpest is usually combated by prophylactic inoculations. Several kinds of vaccine are now available containing either "killed" or "live" attenuated virus. The choice depends, to a large extent, on the type or breed of cattle being inoculated, because the response to live virus vaccination differs from little or nothing in indigenous cattle, to somewhat alarming symptoms in certain breeds of pure-bred and high-grade stock.

For the protection of high-grade and pure-bred dairy cattle inactivated spleen vaccine is employed. A course of vaccine will usually confer protection for from one to four years. Highly susceptible cattle appear to gain a more durable immunity than cattle of low susceptibility and the response to vaccine is better in fully adult animals than in yearlings.

It has been found that once an animal has received a full course of three doses, immunity may be reinforced by a single annual inoculation of vaccine. When using vaccine therefore the recommended procedure is to give every animal a full course of three inoculations of 10 c.c. at weekly intervals once it is over 12 months old. In subsequent years the animals previously treated with a full course receive a single 10-c.c. dose, whilst the yearlings that have come on since the last inoculation receive a full course of three doses.

The other methods of immunization necessitate the use of live virus which, in Kenya, may only be employed by the staff of the Veterinary Department.

The first of these methods to be developed was the double inoculation method, which was introduced into Kenya by Montgomery in 1910. In this method, serum was inoculated on one side of the animal and virus on the other. The severity of the reaction was controlled by the serum and the animal developed a mild attack of the disease, as a result of which adults acquired lifelong immunity. In calves, however, the resultant immunity was not always permanent. There were several disadvantages in the "D.I." technique and this method is not now used in East Africa.

In view of the difficulty and expense involved in preparing large quantities of serum and vaccine, search for a cheap, efficient immunizing agent has been in progress for many years. The only hope of eradicating rinderpest from territories like the East African territories, populated, as they are, largely by backward peoples owning herds of low-valued cattle, lies in the wholesale immunization of stock with a cheap product conferring a durable immunity.

Experiments conducted by Edwards in India showed that when rinderpest virus was passed many times through goats its virulence for cattle decreased. As a result of these experiments, goat virus was introduced in India for the field immunization of the relatively resistant plains cattle. This virus was imported into Kenya in 1937, but was found to be too virulent for use on local cattle. Passaging of the stock Kabete virus had been started in 1936. No evidence of attenuation was noticed until the 85th passage, after which passage the virus became progressively less virulent, and early in 1939, after 270 passages, it proved suitable for use as a field immunizing agent provided that the cattle were in good condition, that grazing was good and that there was no exposure to inclement weather during the reaction period.

Kabete attenuated goat virus (K.A.G.) is, then, the second method available and since 1939 many millions of cattle have been successfully immunized. In addition to being used locally, this vaccine has been sent to West Africa, the Sudan, Egypt and Ceylon. The strain of virus has now been passaged over 700 times in goats and appears to have become fixed in virulence for cattle. Certainly, further attenuation has not been marked over the last 400 transfers.

Goat virus produces a reaction following inoculation, but with ranched cattle, both Zebu and Grade, under good conditions, mortality is negligible and this method of inoculation has become popular in East Africa. Immunity is probably life-long. The ease with which large quantities of virus can be prepared at low cost has enabled inoculations to be done on a very large scale. The effect of these inoculations on the frequency of outbreaks of rinderpest, both in the reserves and in the settled areas, has been very satisfactory; but as wild, virulent rinderpest virus can be spread by game, the time has not yet arrived when farmers can safely discontinue the protection of their cattle.

Japanese workers were the first to show that rinderpest virus attenuated for cattle by passage in rabbits conferred a good immunity in certain highly susceptible stock without any of the untoward reactions observed in these animals when using goat attenuated virus. Rabbit-adapted, or lapinized virus, as it is known, has now been proved and thousands of doses are used annually throughout Kenya. In most cases, lapinized virus when inoculated into local cattle causes no reaction, thermal or otherwise. It is especially useful for the protection of high-grade stock and also cattle in tsetse fly areas. The duration of immunity evoked by lapinized rinderpest virus is over 12 months and it is advised that stock be inoculated annually.

The immune response in calves following inoculation with either K.A.G. or lapinized virus vaccine depends on both the immune status of the dam and on the age of the calf. Calves of immune dams receive a passive immunity via the colostrum which gradually wanes and has disappeared by the time the calf is about nine months old. This immunity tends to interfere with the response to vaccination. Such calves may thus become completely susceptible by the time they are about a year old. Vaccination at this time, however, will be followed by an immune response. Calves of non-immune dams do not receive a colostral immunity and can be expected to respond to primary vaccination.

There still remain, however, a few breeds of cattle, both in Kenya and in other parts of the world, in which lapinized virus produces a marked thermal response with attendant adverse effects, e.g. drop in milk yield. Notable examples are pedigree animals of the "Channel Island" breeds (Jersey and Guernsey) and also Ankole cattle. These breeds appear to have an innate low resistance to rinderpest and their reactions following inoculation of lapinized virus cannot be said to be due to a reversion to virulence or an exaltation in virulence on the part of the virus.

In various laboratories throughout the world, efforts are now being directed towards still further attenuation of rinderpest virus so that it may be suitable for use in the highly susceptible breeds. At the moment, the most promising virus appears to be that attenuated by growth in developing hens' eggs either with or without previous attenuation in rabbits, i.e. "lapinized-avianized" and "avianized" virus respectively.

HIGH ALTITUDE LEY AGRONOMY IN KENYA

III—THE EFFECTS OF LIME AND MOLYBDENUM, AND SOME OBSERVATIONS ON THE USE OF LEGUMES

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(*Received for publication on 6th May, 1959*)

THE EFFECT OF LIME

Except on vlei soils of low pH where marked responses to liming have been obtained with up to eight ton dressings, observation plots have shown little effects from liming grass sown with phosphate. It might be expected, however, that legumes would benefit from the liming of acid arable soils so the following two experiments were done with lucerne.

A 2^4 factorial with two replications was put down in mid-August of 1952 on old arable land of pH 4.9. Ground limestone (84 per cent $CaCO_3$) at three tons an acre was broadcast and dug into the seed-bed a week before Provence lucerne was drilled in 14 in. rows at 12 lb. an acre; superphosphate at 2 cwt., Muriate of Potash at 3 cwt., and sulphate of ammonia at 2 cwt. an acre were also broadcast in all combinations and lightly raked in three days before sowing. In addition 1 cwt. an acre of superphosphate was applied overall in the drill when the seed was sown. No further fertilizers were applied. The plots were scored for growth two-and-a-half months after sowing and it was clear that the complete fertilizer treatment (L, P, K, N) resulted in twice as vigorous establishment and growth as on the controls; plots receiving lime or phosphate were also vigorous but the potash alone treatment was the worst. In April, 1953, the plants were singled to 1 ft. spacing between plants in the rows and four cuts were subsequently taken that year, excluding a trimming cut. By the last cut the lucerne had stopped growing on all plots except those receiving lime. Analysis of the four cuts showed highly significant lime and phosphate effects, and a highly significant P × K negative interaction; the addition of potash to the phosphate reducing yields. Yield increases of some 50, 32 and 4 cwt./ac., fresh weight, were obtained from the L, P and K treatments respectively (overall mean responses). The differential effects showed 43 cwt. extra yield from the lime in the presence of phosphate, compared to its effects in the absence of phosphate; phosphate depressed yields by 27 cwt. only in the presence of potash. In August, 1954, 20 plants on each plot of one replicate were carefully dug up, the roots washed, and the plants classified visually into those nodulating well and into those not nodulating. Results showed that on the control, P, K, and N plots not one plant was nodulating; 10 to 35 per cent of the plants were nodulating on the plots receiving any of the combinations of fertilizers excluding lime, while lime alone, or in combination resulted in 80 to 100 per cent of the plants nodulating. The importance of lime for effective nodulation is thus obvious; the large positive interaction between lime and phosphate on yields is thus explicable, yields being stimulated by the phosphate only when lime ensured nodulation. No reason for the negative P × K interaction can be found on the grounds of nodulation since 35 per cent of the plants on the PK plots were nodulating compared with none on plots receiving either fertilizer alone.

The effect of the lime on soil pH was followed in one replicate. Liming raised the pH to a maximum of 7.2 on the lime-alone plot three years after it had been applied but the overall mean pH figures for the limed versus unlimed plots at that time were 5.88 and 4.95 respectively. There was some free lime still visible in the soil sample from the lime-alone plot and, as there was only a single replicate, the high pH figure of 7.2 is probably unreliable. It is probable, however, that a 3-ton dressing will last usefully four or five years (the experiment was not continued after the end of the third year). Samples of the lucerne were analysed at the end of the third year, the calcium (Ca) content was 2.84 per cent taking the mean of the limed plots, as against 2.52 unlimed, i.e. a 13 per cent increase. The phosphorous (P) content was 0.19 per cent whether limed or unlimed. This is a very low figure for a legume but it had not received any phosphate since the experiment was started three years before. The phosphorous content of the first cut was however only 0.23 per cent on the phosphate plots.

The experiment shows the importance of liming as a soil amendment to ensure nodulation.

A second experiment, using N.Z. Marlborough lucerne aimed at finding if any worthwhile response was to be got from small lime dressings of 4, 8, 16, 32 and 64 cwt. an acre of lime (87 per cent $CaCO_3$) on old arable soil of pH 5.1. As well as the lime, molybdenum was applied at 0, ½ and 3 lb. an acre, in a 6 × 3 factorial with three replications. A previous exploratory experiment had shown that lucerne responded to molybdenum in its first year. The lime was broadcast on the nearly prepared seed bed three weeks before sowing and was raked in; it was not deeply buried. The molybdenum was broadcast using sawdust as a carrier and the seed was drilled in 14 in. rows with a mixture of 1 cwt. superphosphate and 1 cwt. of lime an acre overall. Superphosphate was applied twice annually as a top dressing at 100 lb. an acre the first year and 200 lb. an acre the second year. The first cut was taken seven months after sowing and at intervals thereafter; a condensed summary of eight cuts being shown in Table I. There was no significant lime × molybdenum interaction; the variance of the lime treatments did not quite reach the 5 per cent level of significance but this was expected and a partition of the variance into the highest rate versus the others was highly significant. Over the eight cuts the lime response was linear up to 32 cwt. dressing, each lime increment resulting in an extra 2 per cent yield; the last increment of 32 cwt. of lime, i.e. the 64 cwt. dressing resulted in 6 per cent extra yield and the end of the curve is distinctly curvilinear although overall there was no significant departure from linearity. The greatest lime response came in the first cut, thereafter the effect gradually decreased. The molybdenum produced highly significant effects; the high rate reduced yields significantly compared to the low rate which over the eight cuts did not quite significantly outyield the control. As with the lime responses, the greatest effect of the low molybdenum came in the first two cuts (31 and 12 per cent increase); over the eight cuts a 6 per cent increase and 6 per cent decrease in yield was obtained from the ½ and 3 lb. dressings respectively. The lucerne was nodulating on all plots and it is evident that the drilling of 1 cwt. of lime an acre with the seed ensured nodulation even on the control plots; but it is doubtful if the broadcast small lime dressings are worth the trouble or cost involved. A small molybdenum dressing, however, is easy to apply if superphosphate containing small amounts of molybdenum is used and if, as is indicated, quicker and more vigorous growth is obtained in the early stages of establishment small dressings may be justified. Care will have to be taken, however, that an amount toxic to livestock is not used. As a guide to further work the lucerne from two replicates in the above experiment was analysed spectrochemically by Mr. G. T. Chamberlain of E.A.A.F.R.O. The most

TABLE I.—EFFECT OF LIME AND MOLYBDENUM ON LUCERNE YIELDS, TONS AN ACRE F. WT.

	LIME CWT. AN ACRE													
	0		4		8		16		32		64		MEAN	
CUT	1	1–8	1	1–8	1	1–8	1	1–8	1	1–8	1	1–8	1	1–8
MOLYBDENUM														
0	2·9	43·8	3·9	45·3	4·3	48·2	4·0	45·3	3·9	49·0	4·3	49·0	3·9	46·8
½ lb.	4·3	49·0	4·9	48·5	4·8	47·2	5·4	51·0	4·9	49·6	6·0	52·5	5·1	49·6
3 lb.	3·4	40·7	3·1	41·8	3·2	42·3	4·3	43·2	3·7	44·2	5·5	50·2	3·9	43·7
Mean	3·5	44·5	4·0	45·2	4·1	45·9	4·6	46·6	4·2	47·6	5·3	50·6		

CUT 1 L.S.D. (P 0·01) Molybdenum means = 1·0 tons
L.S.D. (P 0·05) Lime means = 1·1 tons
L.S.D. (P 0·05) Within table = 1·9 tons
C of V 27 per cent

CUT 1–8 L.S.D. (P 0·05) Molybdenum means = 2·9 tons
L.S.D. (P 0·05) Lime means = 4·1 tons
L.S.D. (P 0·05) Within table = 7·2 ton
C of V 9 per cent

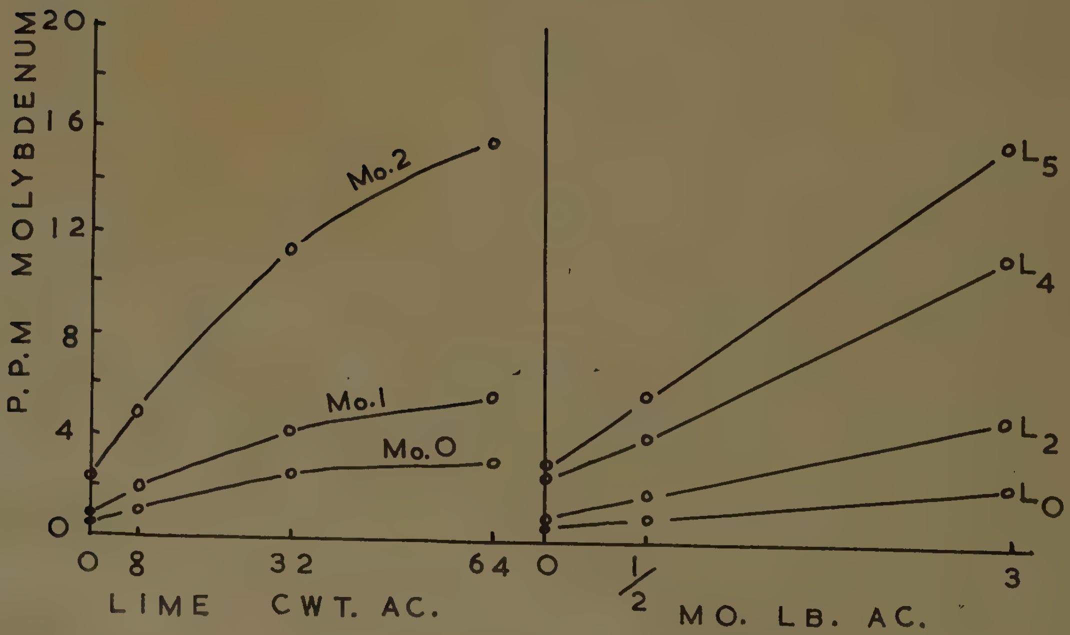
interesting results of the analysis of cut 4 are shown in Fig. I. The molybdenum content of the control was 0.68 ppm. which was increased with increasing lime dressings, even the 8 cwt., dressing being effective in this respect. Without lime the molybdenum content only increased from 0.68 ppm. to 0.83 and 2.35 ppm. at the ½ and 3 lb. molybdenum rates respectively. At the highest lime rate the figures are 3.1, 5.7 and 15.5 ppm. The effect of even small lime dressings on molybdenum availability and uptake is thus apparent. The amount of molybdenum in the lucerne at the high molybdenum rates cannot in any way account for the reduction in lucerne yields on grounds of an interaction with other soil minerals, none of which show any regular changes with increasing molybdenum dressings. Nor is the amount in the plant unduly high, and no explanation can be offered to explain the decrease in lucerne yields with the high dressing.

Other points of interest are the effects of the lime on the concentrations of other minerals in the lucerne. The calcium content rose linearly from 1.35 per cent in the control to 1.70 per cent at the highest lime rate, taking the mean over the molybdenum dressings. The concentrations of copper, zinc and manganese all tended to be reduced by liming. At the control and high lime rates the respective concentrations are, copper 14 and 10 ppm., zinc 73 and 52 ppm., and manganese 150 and 103 ppm. There was very little consistent change in iron, aluminium, magnesium and potash contents. The reduction in availability of copper, zinc and manganese with liming is a well known phenomenon, but it is surprising that under local conditions such small dressings do apparently reduce their uptake by the plant. Much more work is, however, necessary to confirm the truth or otherwise of the above trends under local conditions. It may be concluded, however, that lime does increase lucerne yields but not as much as would be expected. The effects of molybdenum confirm an earlier exploratory trial in producing its main effects during establishment. The uptake of both lime and molybdenum was small.

FIG I

MOLYBDENUM UPTAKE

LUCERNE



THE EFFECTS OF MOLYBDENUM AND ZINC

Since positive molybdenum effects had been obtained on lucerne its effects were tested on other legumes. An observation trial with Serradella (*Ornithopus sativus*) sown uninoculated, inoculated, and inoculated plus molybdic acid at 6 oz. an acre applied with the seed. gave yields from a single hay stage cut of 11, 14, and 17 tons an acre green matter respectively. The molybdenum thus increased yields by 22 per cent.

A second experiment (2^3 with two replicates) was done with the Mount Barker strain of subterranean clover, using ¼ and 2¼ lb. an acre of molybdic acid combined factorially with ¼ and 10¼ lb. of zinc sulphate an acre. The fertilizers were mixed with soil and applied by hand in the open drill furrows before the seed was sown. This experiment was next to the Serradella, on fairly new arable land. One hundredweight of superphosphate and 1 cwt. of lime per acre were drilled with the seed. The first year one cut was taken and the clover then left to seed itself. The second year a top dressing of 200 lb. an acre of superphosphate was applied and another cut was taken. The first cut showed a highly significant molybdenum effect and a significant molybdenum × zinc interaction. The low molybdenum dressing gave greatest increases in yields (30 per cent) in the presence of the low zinc dressing, and similarly with the high dressing combination (41 per cent). Without the high zinc the high molybdenum dressing reduced yields by 7 per cent compared to the control, but not significantly. Zinc alone tended to reduce yields. The second year there were no significant differences between treatments but similar trends occurred as in the first year except that the low zinc dressing increased yields. Spectrochemical analysis of the clover from the control, low and high molybdenum and zinc rates, and from the combination of both at the high rates in the first cut, showed contents of 0.74 to 0.55 per cent Mg, 0.12 to 0.07 per cent Al, and 3.20 to 1.45 per cent Ca, all on a dry matter basis; the Ca and Mg figures were lowest where both zinc and molybdenum had been applied at the high rates. The Fe, Cu, and Mn contents ranged from 136 to 270, 12 to 24, and 188 to 231 p.p.m. respectively there being no consistent changes with treatments. The molybdenum contents were low, the 0.23 p.p.m. in the controls being raised to a maximum of 1.00 p.p.m. at the high molybdenum rate; conversely the zinc contents were high being 153 p.p.m. in the control and 181 p.p.m. in the high dressing combination. Figures for the Serradella are of interest for comparative purposes, the molybdenum contents being five to eight times greater than in the clover.

It may be concluded that, as with the lucerne, molybdenum increases yields of subterranean clover and Serradella. The positive Mo × Zn interaction should however be accepted with caution until further work has been done.

THE EFFECT OF LEGUMES

Only a beginning has been made on this subject since earlier work had to be devoted to other problems. An observation trial of lucerne and cocksfoot in alternate rows, under grazing, showed that an excellent and vigorous mixture could be maintained provided adequate phosphate was used as top dressings. On the other hand mixtures of grasses with the Kenya white clover (*Trifolium semipilosum*) have shown that under grazing no noticeable stimulating effect on grass growth had been obtained by the end of the second season despite adequate phosphate applications. It is considered that this clover is not suited to the high altitude areas as it grows more slowly than the exotic white clovers.

The results of cutting trials of grass/legume mixtures are not directly comparable to the results which can be obtained under grazing but it is of some interest to report one such trial which compared cocksfoot alone with cocksfoot and lucerne in alternate rows. There were four replications of cocksfoot alone, drilled in 7, 14 and 21 inch rows, and also alternate rows of cocksfoot and lucerne with 7, 14, and 21 inches between rows. The plots were sown with S37 cocksfoot and Du Puits lucerne; the soil was poor, old arable (pH 5.0) which was limed lightly at 1½ tons an acre three months before sowing. Sowing was done by Planet Junior at the end of July with 1 cwt. an acre superphosphate and 1 cwt. an acre lime in the drill, and the plots were hand weeded. No weighed cuts were taken in 1956; in 1957 two cuts were weighed and two also in 1958. The figures quoted below should not be taken as showing the total yearly production possible but rather as an indication of the effectiveness of the legume. As the land was very poor it was decided to use large phosphate dressings in the second year. To this end 2 cwt. were applied as a top dressing this season, and 4 cwt. the second season. The grass alone from the first cut outyielded the mixture (total yields of grass plus lucerne) by around a ton an acre F. wt.; in the second and subsequent weighed cuts, however, the reverse was true, the mixture outyielding the grass alone although it was not until the fourth weighed cut that the differences exceeded 3½ tons an acre F. wt., at which time the mixtures were yielding 5 tons an acre against 1½ tons an acre from the grass alone. The totalled yields of the four cuts were 14.9 and 19.5 tons F. wt./ac. (mean over spacings) from the grass alone and mixtures, a significant (P 0.05) difference; the 14 in. alternate rows yielded best. Analyses of the fourth cut grass fractions showed that the crude protein content had been raised by 4 per cent when 7 in. alternate cocksfoot/lucerne row sowings were used, but there was no increase when 21 in. alternate rows were used. In cut four the percentage increase in yield of the grass fraction from the cocksfoot/lucerne mixture in 7 in. alternate rows compared to cocksfoot growing alone in 14 in. rows was 52 per cent, while 66 per cent increases were obtained when the wider rows are compared. It may be concluded that by the end of the second season the effect of lucerne on grass yields and quality can be quite marked, even on poor land. The indications are, however, from other data, that the yields of such a mixture will not be as great as from lucerne growing alone in a pure stand on poor soil.

Green manure crops are used but rarely at the high altitudes and there is no published work on their local effects. The following experiment (four replications) was put down largely to observe the uncut growth and second season regeneration of pure stands of subterranean clovers, but in the second season the regrowth was rotavated in and wheat was sown on top. The clovers were drilled at 12 lb. an acre with a hundredweight of superphosphate at the end of July, 1957 on old arable land. They were top dressed overall with 190 lb. of superphosphate in December. The Dwalganup strain did not nodulate effectively and produced very little leaf and by February, 1958 the Dwalganup was dead; at this time the Yarloop strain was also dead but it had previously grown well; the Clare strain was still just green and the Bacchus Marsh, Mount Barker, and Tallarook strains were all still green, all producing a good cover. At the beginning of July, 1958, following the early rains, the plots were scored for percentage of clover cover (regeneration), were rotavated twice to 4 in., and 294 wheat was sown overall three days later with 1 cwt. an acre superphosphate. An area of fallowed land at one end of the experimental block was also drilled. The plots were subsequently clean weeded by hand, once only.

Early growth of the wheat showed marked colour and height differences, that on Tallarook, Mount Barker, and Bacchus Marsh plots being much greener and up to 6 in. taller than the rest. Two months after sowing a sample cut was taken of the wheat and the produce weighed, while in January the wheat grain was harvested. The results are shown in Table II. Firstly, it will be seen that the wheat herbage yields from the early strain plots (Dwalganup, Yarloop and Clare) were significantly lower than from the late or mid-season clover plots; there is also an obvious linear correlation between yield of wheat herbage and per cent clover before rotavating. There was unfortunately a rather high error for the wheat grain yields and there were no significant differences between treatments. The general trend, however, are clear and follow, as do the wheat straw yields, the early herbage responses in that yields following the early strains of clover were lower than from the late or mid-season

TABLE II.—EFFECT OF SUBTERRANEAN CLOVERS AS GREEN MANURE ON WHEAT YIELDS

CLOVER STRAIN	Per cent Clover cover before rotavating	Wheat herbage Cwt./ac. F. Wt.	Wheat grain Bags/ac. 200 lb.	Wheat straw cwt./acre	Wheat bushel cwt.
Dwalganup	27	42·1	11·3	45·0	64·7
Yarloop	30	50·7	10·8	43·8	64·7
Clare	76	62·2	12·3	51·4	64·6
Bacchus Marsh	69	81·4	12·3	55·9	63·7
Mt. Barker	82	103·9	10·5	64·2	64·0
Tallarook	100	109·3	13·5	63·0	63·1
L.S.D. (P 0·05)	—	25·0	N.S.	15·1	
C of V %	—	22%	20%	18%	—
Fallow	—	106·0	11·4	61·4	63·9

strains, with the exception of the Mount Barker. It is of interest that wheat yields following the Clare strain, which though an early one is far more vigorous than the Dwalganup and Yarloop early strains, equalled yields from the late or mid-season clover plots. There was little difference between bushel weights but there was an indication of an inverse relationship between them and grain yields.

The experiment demonstrates several points of importance. Firstly, herbage yields following quick growing rapidly maturing annual clovers may not only be 50 per cent less than herbage yields obtained from late maturing clovers which have a longer growing season, but 50 per cent less than herbage yields after a fallow. Secondly, wheat grain and straw yields may be less if a quick growing clover is used rather than a slow one. Thirdly, yields of grain from the fallow were not commensurate with its yields of herbage; despite the fact that the fallow produced the second highest herbage yield its grain yield was less than grain yields following the clovers in all except two cases.

DISCUSSION

That lime benefits lucerne has been shown in two experiments but in the first it was not possible to separate its effects as a fertilizer for growth from its effects on nodulation. In the second experiment, however, the lucerne was nodulating on all plots and this was probably due to 1 cwt. of lime an acre being drilled overall with the seed. This result is in line with much Australian work which has shown that a small placed lime dressing helps to overcome nodulation difficulties on acid soils. It is surprising, however, that the larger lime dressings did not give bigger responses. It is likely that there is some other liming factor; but spot applications of gypsum, potash, sodium chloride, and magnesium showed no results. The trace element analysis showed no likely limiting concentrations of the other minerals analysed. The effects of the molybdenum (8 oz. an acre) in this experiment confirmed an earlier trial in that worthwhile responses were only obtained during the early cuts. It is thus likely that sufficient molybdenum is available in the subsoil once the plant gets its roots down [1]. The subterranean clover experiment showed similar molybdenum responses, little effect being obtained in the second year. No explanation can be advanced to explain the depression in yields caused by high molybdenum dressings, in these two experiments. These results, together with those of the Serradella which gave 22 per cent greater yield with molybdenum, indicate that it may well be worthwhile to use molybdenumized superphosphate on annual hay type legumes and also with perennials to get a more vigorous establishment. There is, however, no overt deficiency although the concentrations in the plants was not high.

The effect of zinc in the one experiment is open to doubt in view of the high zinc concentrations in the controls and current experiments are showing no zinc responses. Zinc responses are, however, peculiarly affected by environmental conditions, responses of subterranean clover being more pronounced under long day and high light intensity [2]; deficiency symptoms in the field in Australia are usually most severe in winter but plants recover in summer (loc. cit.). Also, on soils low in zinc subterranean clover can show increasing symptoms of deficiency as the soil nitrogen status is increased [3]. Although the evidence reported in Part II shows that the grassland station's soils are very low in available nitrogen, it is considered unlikely that rising fertility will in the future decisively affect zinc uptake to a point when deficiency occurs since so much is evidently available.

No sulphur responses have yet been obtained on the grassland station except in the case of the deficiency induced by nitrogenous manuring (Part II). The sulphur contents of ryegrass and cocksfoot on the station are around 0.19 to 0.26 per cent. This would seem a normal figure, Walker [4] for example giving a figure of 0.1 to 0.2 S per cent as average. Other authors, however, believe 0.2 per cent to be the lower critical level. It is of some significance that, except for phosphorous and nitrogen, sulphur has been to date the only induced deficiency found on the grassland station and the position needs watching since most of the soil sulphur is apparently in organic form [5] and may become relatively more unavailable as the soil organic matter is increased by ley farming until shortage of sulphur itself limits organic matter build up.

There are certain inherent difficulties concerned with sulphur or gypsum fertilization. Walker [6] found that gypsum increased manganese uptake and availability on acid soils high in exchangeable manganese and that this may lead to poorer clover growth. Quastel [7] reported similar results with peas, oats and beet, and found that S increased divalent soil manganese and its uptake, before, there was any pH effect. Morris [8] showed also that $CaSO_4$ increased the manganese uptake of sweet clover and lespedeza. These results may explain not only the lack of any S responses on the grassland station, but the vagaries of gypsum responses elsewhere in Kenya. This leads to a consideration of the manganese content of plants. It will be seen from Table III that the manganese contents of all the high altitude species so far analysed are fairly high, but it is difficult to find data in the literature which are relevant to the question of legume efficiency, as distinct from visible toxicity, and manganese content. It is well known that plants vary far more in their manganese contents than in respect of the other trace elements. Normal levels in pastures are between about 30 and 140 ppm., while actual toxicity may not be reached until about 1,000 ppm. are present. However, Morris concluded that 400 to 500 ppm. was the critical toxic level in sweet clover and Lespedeza. Walker [6] quotes other authors that the efficiency and growth of lucerne may be reduced when the manganese content reaches about 150 to 200 ppm. and that with white clover nitrogen fixation may be harmed if the manganese concentration is above 80 ppm. Davies [9] stated that the yields of subterranean clover were inversely related to its manganese content. In view of these results it is not impossible that the nitrogen fixing efficiency of legumes may well be depressed on Kenya's acid soils at high altitudes. The manganese problem obviously requires more investigation. Of the other trace elements summarized in Table III, the aluminium concentrations are not high. The iron contents seem normal, but comment is not possible as iron may be present in large quantities and yet be "immobilized" as far as metabolic processes are concerned. Heavy lime dressings have not, however, ever produced chloroses which might be attributable to iron

TABLE III.—MINERAL CONTENT OF PASTURES

	PER CENT D.M.					PPM. D.M.							
	Ca	P	K	Mg	Al	Fe	Mn	Cu	Zn	Mo	Co	B	Ref.
TEMPERATE (EXAMPLES)													
Average English Pasture	0·71	0·32	2·64	0·15	—	—	—	7–21	—	—	—	—	A
Cocksfoot U.K. ..	0·42	0·26	2·31	0·22	—	200	45	10	—	—	0·14	—	B
P. Ryegrass U.K. ..	0·46	0·26	1·97	0·21	—	252	22	8	—	—	0·15	—	B
Lucerne U.K. ..	2·14	0·40	2·60	0·55	—	291	37	9	—	—	0·15	—	B
Anthoxanthum oderatum, Moorland ..													
Anthoxanthum oderatum, Moorland ..	—	—	—	—	—	41–111	200–840	4–8	30–51	0·2–1·5	—	—	C
Mixed Herbage, Scotland	—	—	—	—	—	62–184	120–870	3–10	30–68	0·2–1·2	—	—	C
KENYA, HIGH ALTITUDES													
Veldt..	0·35	0·13	1·07	0·14	—	—	—	6	—	—	—	—	D
Cocksfoot, Molo ..	0·39	0·16	2·95	0·21				8					
P. Ryegrass, Mau Narok	0·41	0·34	1·88	0·14				8					
T. johnstonii, Mau Narok	1·15	0·28	1·43	0·17	0·04	93	108	9	61	1·2	0·05	17	
Sub-clover, Mt. Barker, Molo ..	2·60	—	—	0·70	0·07	136	211	15	153	0·23	—	—	
Sub-clover, Dwalganup, Molo	1·42	0·17	2·32	0·22	—	—	—	—	—	—	—	—	
Sub-clover, Dwalganup, Molo	0·65	—	—	0·40	0·01	45	178	7	185	0·13	0·12	16	
Sub-clover, Dwalganup, Molo	2·40	—	—	0·51	0·08	106	173	10	107	0·16	0·05	17	
Lucerne, Molo ..	1·37	—	2·18	0·43	0·26	802	150	14	73	0·68	0·11	—	
T. tembense, Molo ..	0·75	—	—	0·41	0·26	507	223	7	128	0·37	0·16	40	
Serradella, Molo ..	—	—	—	0·43	0·09	275	367	—	193	1·9	0·04	—	
T. rueppellianum, Molo	0·91	—	—	0·32	0·01	98	155	8	138	1·1	0·06	32	

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deficiency. The copper contents are not high but not abnormally low; no major effects from copper fertilization have been obtained but evidence which will be reported elsewhere suggests that granular $CuSO_4$ is leached or "fixed" very quickly in the soil in unavailable form. The boron contents would appear to be on the low side but no overt deficiency is suspected. Cobalt contents are low but this is generally held to be unessential for plant growth. Of the major elements the potassium and magnesium figures are comparable to those of temperate countries.

The present evidence shows that there are no overt trace element deficiencies but that the Mo, S, Mn, complex would well repay study on a long-term basis. The fact that various interactions, such as Mo × Zn, P × Mg, P × Cu, and Mg × B (this last being in a current experiment) have been obtained, indicate that a general low fertility problem is involved rather than a specific one. Furthermore the indications are that the uptake of applied Ca, Mo, Zn, and to a lesser extent P, is small in relation to the size of the dressings used. The uptake of ions by plant roots is well known to be intimately correlated with plant respiration, and low night temperatures, which fall to around 35°F. at ground level throughout the year, may be responsible for the small mineral uptake and consequent comparatively small yield responses of herbage plants in the high altitude environment. The paradox may thus arise, therefore, in that the mineral amendments which are necessary for the growth of plants on an apparently poor soil will only be partially effective because their uptake is limited by factors beyond control. The final analysis, therefore, resolves itself into a problem of plant physiology, as indeed must any problem concerned with plant growth.

Finally, the complex grass/legume association is considered in relation to the environment for effective legume growth. The implications arising from the local high altitude climatic factors such as short days and comparatively low temperatures discussed in Part I, together with the possible effects of manganese on legume efficiency, may well affect the practice of legume growing at high altitudes. It is thus worthwhile considering if the results of the legume experiments reported earlier conform or not with theory. The green manure experiment showed that the yields of wheat herbage following the early rapid maturing subterranean clover strains were only half those obtained from wheat following the later maturing strains or a bare fallow. Mann [10] has shown that green manures do not benefit the succeeding crops under English conditions unless the above ground herbage is ploughed in and the following crop is sown soon after its burial. The subterranean clover experiment fulfilled both these conditions, so it must be concluded that under local conditions rapidly maturing annual clovers may actually depress soil fertility rather than raise it.

The phosphate experiment described in Part II, also used subterranean clover (Bacchus Marsh), but under cutting conditions which entailed the removal of the produce. The oat yields following this vigorous well-phosphated clover were not significantly higher than those from plots bare fallowed for six months without any phosphate at all. This is remarkable in view of the importance of phosphate for growth, but interpretation is difficult because of the complicating factor of soil moisture when comparing bare fallow plots with clover. The clover in this instance was a mid-season strain, but even so there was nearly 6 per cent less crude protein in the oats following the clover than when the oats followed a bare fallow without phosphate; yields of oats being similar in both cases. The cutting and removal of the clover has thus lowered the available soil nitrogen. The results are in line with many others reported in the literature in that cut legumes do not benefit succeeding crops. There are fewer reports, however, of cut legumes so obviously reducing available soil nitrogen. The reasons will lie in the climatic and soil factors discussed earlier. From these it could be inferred that the legumes with the longest growing season would be the most efficient and the subterranean clover experiments support this view. Although, of course, this principle is true of any climate the evidence suggests that it will be more important at the high altitudes in Kenya than elsewhere.

At the other end of the scale, lucerne, which is most drought resistant and which has thus a long growing season, has been shown to increase grass growth and quality by 50 per cent in its second season even when cut and the produce totally removed. This increase is unlikely to be due to a saving in soil nitrogen which the grass uses, but to an actual below ground transfer of nitrogen from the lucerne. Lucerne can, therefore, be assumed to be the best legume for high altitude on all but the poorest soils. Both practice and experiment support this view and in practice there is one over-riding factor in favour of lucerne. If it is drilled in wide rows alternating with the grass, only half or a third of the phosphate which would otherwise be needed under broadcast conditions need be applied as top dressings. It is a simple matter to run a fertilizer drill along the rows with the spouts only open above lucerne.

The efficiency of the white clovers has not yet been assessed. On the grounds of day-length and temperature, and also because white clover is markedly affected by dry weather, it can be predicted to be less effective than lucerne because it has a shorter growing season. Current trials will prove the truth or otherwise of the above theories but it must be emphasized that a minimum of 150 lb. of nitrogen is required yearly for moderate production in a climate which produces only 10-15 lb. of available soil nitrogen a year for the grass under a sward (estimated from the nitrogen content of grass plots under cutting). The below ground transference of nitrogen to the grass has already been inferred from the lucerne experiment but transfer of nitrogen from the top growth of legumes to the soil through the grazing animal will probably exceed any such below ground transfer under local conditions. A 26 ton fresh weight crop of lucerne or vigorous subterranean clover containing 20 per cent crude protein contains about 170 lb. of nitrogen. If 4 per cent of this is retained by a sheep [11], and allowing six sheep an acre and a one-third loss of nitrogen through leaching and volatilization, there must be a net gain of some 100 lb. of nitrogen per acre. This is equivalent to 500 lb. of sulphate of ammonia and it is clear that ley production could be stimulated considerably by top growth of legumes when grazed. Production depends, however, on using enough phosphate, on only using vigorous annual legumes with a long growing season sown at a high seed rate to give a dense stand, or on using perennial legumes with as long a growing season as possible.

SUMMARY

Observations are made of the grosser factors of climate, soil and fertilizers as they affect the growth of legumes and grasses at high altitudes. The high altitude climate is colder during the growing season than is the climate of temperate countries during their late spring and summer. Soil temperatures are low and without fluctuation. This, and a less pronounced dry season than at lower altitudes results in little mineralized soil nitrogen and as a consequence nitrogen deficiency limits grass growth to a greater extent than at lower altitudes. Phosphate is limiting, and large dressings are needed for optimum growth of legumes and grass during establishment, under broadcast conditions. Transitory responses to molybdenum and lime are obtained. Trace element analyses and experiments reveal no overt deficiencies but it is possible that the manganese concentration might reduce legume efficiency. The factors affecting legume efficiency are discussed in the light of experimental results and it is concluded that quick annual legumes may depress soil fertility compared to annuals with a long growing season. Lucerne, with its long growing season is the best legume for leys so far used; on *a priori* grounds white clover would be expected to be less efficient than lucerne for leys.

ACKNOWLEDGMENTS

I am most grateful to Mr. G. T. Chamberlain, Spectrochemist at the E.A. Agriculture and Forestry Research Organization, for his interest and spectrochemical analyses, and to Mr. D. Howard of the Veterinary Department for permission to quote from his unpublished mineral survey.

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A SURVEY OF THE USE OF MAIZE STALK BORER CONTROL METHODS IN EAST AFRICA

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(*Received for publication on 27th July, 1959*)

As a result of experimental work by the Government and by commercial firms, the use of insecticides for control of the maize stalk borer, mostly *Busseola fusca*, is steadily increasing in East Africa. This interest in insecticides is due to direct extension work by the field agricultural staff and entomologists, by direct demonstration and pressure from representatives of the trade, and by such indirect means as magazine and newspaper articles, broadcast talks and trade shows. The interest is shown by all sections of the community, from primitive non-Swahili speaking tribes to the progressive readers of American farming journals.

An account of the change in the methods of control which has taken place in East Africa since the war has not been published, and there is no statistical estimate of the extent to which modern methods are being used, probably because of the difficulty in obtaining one. This survey was carried out in 1957, and is based on a number of estimates and opinions provided by agricultural and commercial staff and farmers, and should not be taken as being more factual than this. It may be subject to bias, for instance in estimates of the quantity of insecticide used. The best it can achieve is to give an idea of the progress made in the use of insecticides for stalk borer control and to show the need for more accurate and recent statistics on the insecticide application equipment in use in different areas.

In those parts where stalk borer occurs (Swaine, 1957; Nye, in preparation; Ingram, 1958; Walker, 1957), some division of the types of farm and farmer must be made in order to arrive at any general conclusions. The following uneasy stratification is still effective, although many African holdings can now rightly be classed as estates on account of their increasing wealth and mechanization. Broadly, maize growing can be divided into the following three categories:—

(*a*) Non-European, mostly African, primitive peasant holdings, usually from two to nine acres of cereals, often scattered and irregular in shape, often intercropped with peasant-type crops.

(*b*) Non-European, mostly African, smallholdings of the same size but progressive, and tending to include more cash crops such as coffee, cotton or vegetables.

(*c*) Mostly European, but with increasing numbers of African, estate farms, using mechanical equipment and employing labour. Great range of size, but many 500-2,000 acres.

PRIMITIVE HOLDINGS

Very little information is available on the extent to which African peasants are applying insecticides for stalk borer control. Where activity occurs it is often due to the presence of a research station or enthusiastic agricultural staff. Even so there is still apathy about accepting and applying insecticide and occasionally an undercurrent of political or personal prejudice in some places.

The position is improving with the interest shown by commercial firms. Two factors which have resulted from this are the appearance of small packets and bottles of modern insecticides for sale in village shops, and the production of leaflets, instructions and attractive posters in several vernacular languages. The schools are also helping to spread a knowledge of insecticides.

In the Western Province of Tanganyika, following trials by Swaine (1957), the use of 2½ per cent D.D.T. dust is increasing, and it is used quite widely in the Tabora district. Despite trials further away from Tabora, however, the local people continue to show no interest, and the major problem is still to encourage good husbandry in planting, cultivating and disposing of refuse after harvest. In the Northern Province highlands, D.D.T. dust has been shown to give heavy increases in yield (Walker, 1957), but the use of D.D.T. dust throughout the district can hardly be called extensive, and recently did not exceed a few hundredweights. In the Meru and Kilimanjaro districts of Tanganyika and the Mount Kenya and Elgon Nyanza districts of Kenya, D.D.T. dust was also being sold locally in terms of hundredweights and is being used on maize.

The usual method is to place a small quantity of dust in the maize funnel with a tin scoop, although Swaine (1954) has described a simple duster which can be locally made from a tin. Any type of sprayer is usually beyond the resources of the primitive peasant.

PROGRESSIVE SMALL HOLDINGS

On these insecticide is now being bought by Africans for pest and disease control on their cash crops. Examples of this are coffee on Kilimanjaro and cotton in Eastern and Lake Provinces of Tanganyika and on several crops in Uganda.

The tendency is for hand dusters and pressure sprayers to be bought, particularly if an active "Co-operative" has been formed. D.D.T. dust is still the material most widely used, and is being bought for stalk borer control in small quantities in the Mount Kenya area, near Nairobi, among the Chagga in Tanganyika, and in Nyanza and Uganda.

ESTATE FARMS

It is on these that the greatest mechanization has taken place, and most of the information in this survey applies to this type of farming.

In Kenya, most of the farms where stalk borer is a potentially serious pest of maize lie in the Rift Valley and in the maize-growing areas up to Kitale. The numbers of farms growing maize in these areas are approximately as follows (Kenya, 1955 and 1957/58):—

	Between	*Acreage of Maize (average)*
Trans Nzoia:	350-370	190 (very wide limits)
Uasin Gishu:	370-450	110
Nakuru:	310-430	100
Other areas:	310-500	—

From figures of the number of tractors in different areas in 1954, it can be concluded that an average of one per farm was used, although this figure is sure to have risen since that time, and is more likely to be at least three for farms which grow a large acreage of maize.

Among these roughly 400 farms per district therefore, each with at least two tractors and probably at least 100-200 acres of maize, estimates of the number which applied any insecticide treatment at all were as high as 80 per cent. Other estimates were from 60 per cent to an average of about 70 per cent, which suggests that by 1957 about 280 farms were applying some insecticide treatment out of the 400 in each of these maize growing areas. There is probably a gradient from progressive farmers in places like Rongai where stalk borer infestation can be heavy to Molo and Timboroa where it appears to be less, but few counts of the amounts of stalk borer have been made in different areas.

What methods are used? The most common is still the application of a small quantity of D.D.T. dust, usually 2 per cent or 2½ per cent, by hand by means of a small scoop or teaspoon. Treated plants can be seen and when labour is not a limiting factor, which it is on some farms, the method is effective. It is estimated that one person can treat 7 acres a day. Much of the dust used is locally formulated from diatomite and D.D.T., but diatomite is not always suitable due to bridging in the duster when moist. A concentration of at least 2½ per cent D.D.T. has been shown to be necessary, and on a high yielding, heavily infested crop, 5 per cent dust will repay its cost (Walker, 1957). The scoop method may use the same amount of dust as a dust-gun, for instance a teaspoonful per plant can be equivalent to 5 to 10 lb. per acre. A primitive dust-gun can be effective when delivering 5 lb. per acre.

Hand liquid application with a bottle and spout is still commonly used, and Derris emulsion has been most popular, particularly in the Uasin Gishu. Its supply, however, now appears to be restricted in favour of D.D.T. emulsion, and this is used at about 0.09 per cent. Sheep dip, based on BHC, has also been used but is likely to cause scorch. One opinion was that dust was used in hot weather and liquid, by bottle, in dry.

A few knapsack sprayers are used in Nakuru and Kitale. Another refinement is the addition of a water-soluble dye, so that progress can be followed.

No figures are available of the actual number of farmers possessing tractor-drawn sprayers, although the number in use for weed-killing must be increasing each year. Some general estimates were obtained however, and it seems that in 1957 an average of 16 per cent of those maize growers who apply insecticide for borer do so by tractor-drawn sprayer. Actual estimates varied from 1 per cent to 25 per cent, probably depending on the immediate contacts of the source of information. Farmers and agricultural staff tended to agree on a figure of 10 per cent. This implies that of the 400 farms in each district about 30 use a tractor-drawn sprayer for stalk borer control. This figure is probably higher in the Nakuru area where cereals necessitate selective weed-killing, and less in the Trans Nzoia where maize and cattle are more common.

In support of these figures, and as an indication of the extent of insecticide used, some general inquiries were made about the amount of D.D.T. used in the three main areas above.

The Trans Nzoia appears to be the largest consumer of D.D.T. dust, as would be expected from the large maize acreage and the influence of stalkborer trials in the district by LePelley, Graham and Smith for a number of years. Up to 50 tons of dust, mostly 2½ per cent, appear to have been consumed annually, and 150-200 gallons of D.D.T. emulsion. In Nakuru much less dust is used, probably under ten tons, but about the same quantity of emulsion, while in the Uasin Gishu relatively smaller amounts of about six tons of dust and a few gallons of emulsion are applied. It seems that a hundred or more tons of D.D.T. dust and perhaps 500 gallons of emulsion were being used at the time of the survey for stalk borer control, but as all sources could not be investigated this estimate may be unreliable.

The imports into Kenya from the United Kingdom in 1957 (U.K. 1957) amounted to about 650 long tons of insecticides, fungicides and rodenticides, and as the proportions from other countries (combined with disinfectants), were approximately 60 per cent from the United Kingdom, 17 per cent from South Africa, 10 per cent from United States and 1 per cent each from Germany, France, Holland and Denmark (Kenya 1957), it might be assumed that 1,000 tons of these combined products were imported into Kenya, of which perhaps 500 tons were insecticides. Much of this will be concentrate for local insecticide manufacturers, retained as stock or destined for re-export, but the figure is instructive as an indication of the insecticide usage of the country.

The relative import figures for Tanganyika and Uganda, of insecticides, fungicides and rodenticides, from the United Kingdom only, are 110 long tons and 170 long tons respectively.

Any greater detail, except for further breakdown of import and export figures for insecticides alone, could only be obtained from some knowledge of the output of locally manufactured insecticides and a survey of the quantities actually used by a sample of farmers. Such information would be of great scientific and commercial value.

Other points of interest where differences are found in stalk borer control practice concern application, namely whether to, when to and how many times to apply insecticides. Many farmers still apply their Derris, D.D.T., Endrine or Malathion once only as a "spot treatment" on damaged plants only, when signs of damage are seen. It has been shown by work in South Africa (Anderssen, 1946) which has been found to be true in Kenya (Walker, 1957), that visible signs of damage take up to ten days to appear in an infected plant. If insecticide application is delayed as long as this larvae may not be killed and loss in yield can be expected. The most effective control will result if insecticides are applied soon after the eggs, which are laid under the lower leaf sheaths, hatch. This may occur when the plant is only 8 inches high, so that height is no reliable criterion. Another reason for observing the amount of egg-laying is that an idea of the amount of infestation will help the farmer to decide whether to spray or not. The relation between the amount of infestation and the yield has been found for high and low yielding crops in Tanganyika (Walker, 1957) and it is obvious that similar information must be got from other areas before there is a scientific basis for deciding whether or not to spray.

Work in Tanganyika has shown that egg-laying lasts for a definite period of up to six weeks and this seems to be the same in Kenya. As insecticide treatment lasts up to two weeks, or possibly longer with endrin and granule formulations, it is necessary to repeat applications at least three times for maximum control. Many farmers in Trans Nzoia and Uasin Gishu now apply two dressings, with three to four weeks' interval between, and treat the whole field as a routine. Only continued trials on these factors, such as the work of Bullock (1956) will lead to complete understanding.

Although some of the information given above is in the nature of estimates and opinions it shows to what extent the results of research are being applied by the farmer. The ways in which this knowledge can be expanded and made more accurate are outlined. More statistics of the number of tractor-sprayers in use are required, together with their capacity and pressure; a further breakdown of the import statistics for insecticides and other pesticides; and a survey of the amount of insecticide actually used by farmers. The latter figures would be of particular interest for African holdings, as this is where the greatest increase in consumption can be expected to take place.

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REVIEW

Vegetation Map of Africa (South of the Tropic of Cancer), compiled by L'Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale, 1959. Published by Oxford University Press, pp. 24 and folding map, price 15*s*. (in U.K.).

A very frequent enquiry received by botanists working in various parts of tropical Africa is for a vegetation map on a broad scale. Such has not been readily available save in books long out of date and in any case these early maps are small and inaccurate. The present map, which was envisaged at a conference of A.E.T.F.A.T. several years ago, will be invaluable to ecologists and other workers who are trying to correlate distributions of organisms or other phenomena with vegetation patterns.

The map itself, which is enclosed in a flap at the end of the paper-bound pamphlet, measures 83 by 75 cm. and 19 colours or symbols are employed to cover 35 different vegetation types. It has been compiled by sending portions of a blank map to various contributors and then editing the portions into a whole. Each portion has been drawn by a person or several persons with a wide field knowledge of the areas concerned and also a knowledge of systematics. The map is not therefore a hazy distribution of vegetation types based on the mere habit of the constituent plants which is often the case with earlier maps. The chief fault of such a map is that, for workers in any given area, the scale is too small and interesting vegetation types of small extent frequently have to be omitted. Where fine detail is important then this map will be of little use but to any person wishing to know the type of vegetation pattern that exists over a large tract of tropical Africa then it will be of great value; in fact there exists none other he can conveniently use.

The 24 pages of explanatory notes (in French and English) are compiled by R. W. J. Keay and consist of very brief descriptions of the vegetation types. There is an excellent bibliography.

B.V.

THE CULTURE OF TILAPIA NIGRA (Günther) IN PONDS

III—THE EARLY GROWTH OF MALES AND FEMALES AT COMPARABLE STOCKING RATES, AND THE LENGTH/WEIGHT RELATIONSHIP

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(*Received for publication on 27 June, 1959*)

The basis of the monosex technique recommended by this Division for the culture of *Tilapia nigra* in ponds is the marked sexual dimorphism in growth between males and females (Brown and van Someren 1953, Brown 1956, Brown 1957).

The males at all times, almost from hatching, show a growth rate superior to that of the females, this greater growth being still marked even after maturation (van Someren and Whitehead, 1959 (*a*)), though it is slowed by a high stocking density resulting from unrestricted breeding. Female fish on the other hand show a slower rate of growth; thus in a pond where males and females are stocked together, and breeding is allowed, the growth of the stock fish may be much reduced, and the growth of the resulting fry even slower (van Someren, 1953). It is now believed that such slow growth in overstocked conditions results not so much from maturation, as from the high population density which results from the breeding activity.

The isolation of the faster growing males does not prevent the onset of maturation, but prevents breeding and thus population increase; and thus allows the limited number of fish to exploit the growth potential of a pond to the full, ensuring that every fish reaches a large size, and not just a few only as in a mixed pond.

In *T. nigra* at least, this sexual dimorphism in growth is probably genetically controlled, and while it is shown under all circumstances of growth, there are few data available as to the actual differences attainable; and in themselves the differences in growth between sexes are variable according to population density.

The present results therefore delimit the variability of male and female growth at two comparable stocking densities, 200 fish per acre, and 400 fish per acre, data for the latter being adapted from Brown's (1957) observations.

METHODS

The experiments were conducted in quarter-acre and half-acre ponds at the Inland Fishery Research Station of this Ministry, at Sagana in Kenya.

In Brown's experiments, both males and females were grown at a stocking rate of 400 per acre in each of two separate quarter-acre ponds held at a water depth of two to three feet. In the present experiments the males were grown in a half-acre pond at a stocking rate of 200 per acre, in clear water averaging one foot in depth; the females were grown at a similar stocking rate in a quarter-acre pond, also held at one foot water depth, of comparable clarity to the male pond. The depth of water and degree of clarity have already been shown to exert a marked influence on fish growth (van Someren and Whitehead, 1959 (*b*)), growth being much better in shallow clear ponds than in deep or turbid ponds.

Recent work has also shown that the growth rate of fish at a known density tends to be less in a smaller pond than in a larger pond at a similar density; and that growth tends to follow a seasonal pattern, being slower in the cloudy months of July and August than in the hot dry months of January to March, and September to October. This latter is almost certainly a direct effect of lower mean water temperatures in the cloudy months.

Brown's experiments were conducted from May to October, 1956; the present series from August 1958 to January 1959 for males, and December 1958 to May 1959 for the females, ponds not being available to carry out simultaneous experiments. The pattern of mortality and survival in Brown's experiments is not known, but survival in the male pond was stated to be 100 per cent at the end of six months, a high figure which has never been equalled. In the present experiments mortality was estimated monthly from the proportional recapture of individually tagged to untagged fish in one seine haul, and final survival by a total count on draining the ponds. In these experiments only 75 per cent of the males survived the six months, and only 35 per cent of the females. The female pond had not been subject to quite the same degree of control as the male pond; predation by birds and mongoose probably being higher. The figure of approximately 70 to 80 per cent survival of males has been repeated in several other experiments, and appears to be general under conditions prevailing at Sagana. The heaviest mortality appears to occur within the first two weeks after stocking. Survival affects the total population density, and hence the growth rate; the lower the survival, the greater would tend to be the growth rate of the survivors up to a point.

Additionally, Brown's fish were stocked at a smaller size than those in the present series, and as the growth curves show, the smaller the fish on stocking the greater the initial growth rate since the growth rate increases steeply at first and then slows to an asymptotic curve.

Therefore all the differences in experimental conditions outlined above, such as time of experiment, size of pond, water depth, clarity, survival and initial stocking size would have served in each instance to emphasize the differences found, both as regards comparison of stocking rates, and the growth of males and females at comparable stocking rates. Nevertheless the results show that sexual dimorphism is present to a marked extent, and they are presented in justification of this method of culture.

RESULTS

The average monthly measurements of all fish are graphed in Fig. 1. together with the monthly increments, netting recoveries and survival rate for the present experiments. The whole pattern of growth is not shown, only the growth in a six-month period. Growth rate prior to that shown is steeper, and later to that shown would be slower, the curves almost certainly following the von Bertallanfy formula (Beverton and Holt, 1958).

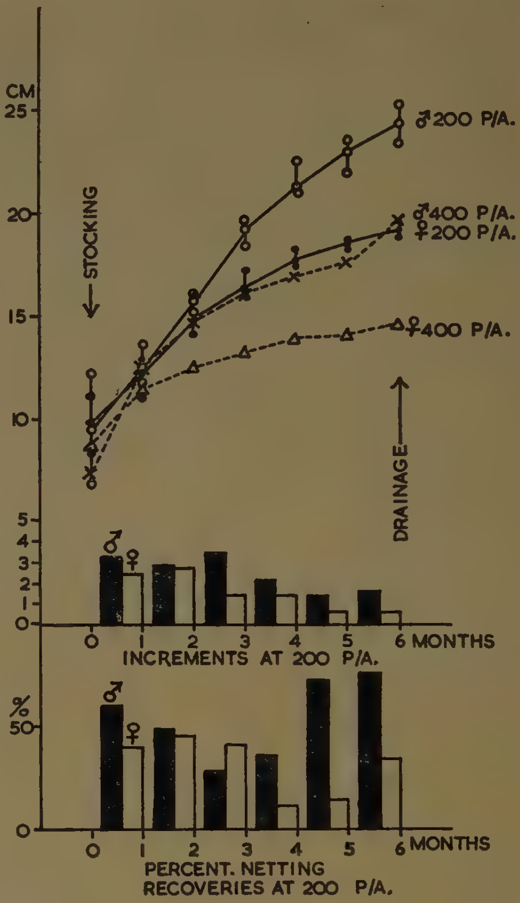

Fig. 1.—Growth of male and female *T. nigra* at 200 and 400 fish per acre

In both series of experiments close observation of the female ponds ceased six months after stocking for the same reason—that breeding had occurred. In the present experiments, sexing had been at fault and one male only was found among forty-nine females stocked, after the first month, and within that month no less than five of the females were found to be carrying eggs in their mouths. In Brown's experiments, females were also found to be incubating eggs after the first month, the supposition being that brooding females had been inadvertantly included during the sexing operations prior to stocking, which is easy to do unless the mouth of every single female is opened before stocking. Although in both series all fry netted out each month were rigorously destroyed, it is not possible completely to eliminate all fry every month without total drainage. By the end of six months in a monosex pond which has thus been contaminated, the stocking females are mating with their own progeny and population control is no longer possible, growth rate being affected accordingly. Up to that time however, the growth rate of the stocking fish is hardly affected. As Brown has stated, this is the real danger of trying to grow females only, since an incubating female is easily overlooked in an original stocking.

Even if exaggerated by the conditions mentioned previously, the curves in Fig. 1 indicate clearly that at both stocking rates used (and probably at any stocking rate), the growth of males is at all times greater than that of females, both in actual rate, and length achieved at any given time. For the 200 per acre experiments, the vertical lines at each month show the range of sizes at that month. Though the initial range may be large, after six months all fish have achieved practically the same length on an average for each sex respectively. This is merely an indication of the fact that within limits, the smaller the fish on stocking, the faster it grows within a given period; its growth rate is in fact on the same curve, but at an earlier, steeper, part of it.

Figure 2 shows the Ford-Walford growth plot (Beverton and Holt, 1958) of the male and female fish at 200 per acre, Lt (length at any time *t*) being plotted against Lt+1, 1 in this instance being the increment one month later than Lt. The difference in growth between the sexes is well shown, and though no attempt is made here to interpret the slope of the lines (which have been fitted by eye only) in terms of the von Bertallanfy equation, these lines have been extrapolated to an intersection with the bisector to indicate the asymptotic length which each sex would reach at this stocking rate; in the case of the males, 31.5 cm., and only 21.5 cm. for the females. Such a plot does not indicate time, but other experiments still in progress with males tend to confirm these asymptotes, though the period is longer than 12 months.

These experiments indicate growth of fish under these conditions without fertilizers or feeding, and other experiments to determine growth and yields of males under monosex culture at different stocking rates, without additives, up to 1,000 per acre are not yet concluded. Two hundred fish per acre is a low stocking rate, but whether growth rate would be much increased at a still lower rate is doubtful. In shoaling fish such as *T. nigra*, growth is partly a function of ethological factors, and there is probably an optimum stocking rate with a given food supply, at which maximum growth is achieved.

However, to determine whether very low stocking rates can in fact markedly increase growth rate, two further experiments have been made in shallow quarter-acre ponds at Tebere, stocking five fish only in each (i.e. 20 per acre), and at Sagana, stocking only one male fish in a one acre pond. These fish have not been measured regularly, but Table I details the periodic measurements which have been taken.

They indicate that on such a *reductio ad absurdum* basis, it is not possible for male *T. nigra* of the stocking sizes used to exceed a growth rate of about 4.5 cm. per month, this being a physiological limit which is in fact not much in excess of that achieved at ten times, or two hundred times the stocking density. Nevertheless a growth rate of approximately 1 cm. per week is notable for a cichlid fish.

DISCUSSION

Although de Bont (1950) claimed a sexual dimorphism in growth in *T. melanopleura*, this was not confirmed in Kenya by van Someren and Brown (1953), and no other *Tilapia* species

TABLE I.—GROWTH OF MALE *T. nigra* AT MINIMUM STOCKING RATES

DATE	DENSITY PER ACRE		NO. RECOVERED		AV. LENGTH (CM.)		INCREMENT (CM.)		AV. WEIGHT	
	Pond D3	Pond D4	Pond D3	Pond D4	Pond D3	Pond D4	Pond D3	Pond D4	Pond D3	Pond D4
16–9–58 (stocking)	20	20	—	—	11·0	10·9	—	—	—	—
3–12–58	20	20	4	4	21·6	21·9	10·6	11·0	—	—
18–2–59	20	20	2	4	25·9	26·1	4·3	4·2	—	—
13–5–59	20	20	5	2	27·0	28·4	1·1	2·3	1 lb.	1 lb.
	Pond B1									
21–11–58.. ..	1		—		11·0		—		—	
3–6–59	1		1		30·5		19·5		—	

NOTE,—Ponds D3, D4 each ¼ acre, stocked five fish each. Pond B1, one acre, stocked one fish.

apparently show the same kind of sexual dimorphism either in genital morphology or growth as *T. nigra*, except the very closely related *T. mossambica* and its subspecies. There are indications that under certain environmental conditions *T. nilotica* may show related features in differential growth of the sexes (Lowe-McConnell, 1958), but the mechanism does not appear to be the same.

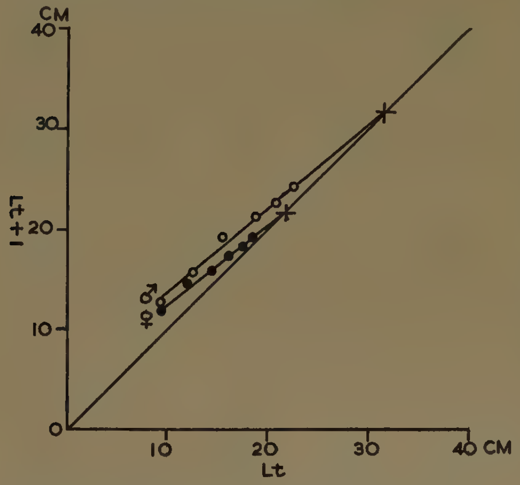

Fig. 2.—Growth of male and female *T. nigra* at 200 fish per acre (Ford-Walford plot)

T. mossambica is now widespread over most of the tropical regions of the world (Hickling 1954), and monosex culture to achieve the best yield of individual fish was advocated for this species by Vaas and Hofstede (1952), and later Hickling (*loc. cit.*).

Only Vaas and Hofstede (*loc. cit*) have published figures for growth of males and female *T. mossambica* under comparable stockings, and Table II is adapted from their figures. They are by no means comparable with the present results for *T. nigra*, since the stocking rates used by these authors approached 4,500 per acre, the initial stocking sizes were much smaller, and the environment different. Under these conditions the increment for the first month after stocking was larger than any so far recorded for *T. nigra*, an effect possibly of the small stocking size, and *T. nigra* might well show the same. Thereafter in the second month there is a large fall-off in increment as would be expected with such a high density of fish.

These authors however concluded from these figures that "if the females are unable to spawn, owing to the absence of males, their growth rate practically equals that of the males", but that their growth is checked early if allowed to breed together with males. Somewhat similar claims have been made for this species under culture in Jamaica (personal communication), but no details are available. While it may be that *T. mossambica* does differ in this respect to *T. nigra*, only two months observations of growth is too short a period to be categoric on this point, and indeed the slight fall off in female growth indicated in Vaas and Hofstede's Pond 13 may well become accentuated as in the present results for *T. nigra*, over a longer period.

LENGTH/WEIGHT RELATIONSHIP

The average relation of length to weight in male and female *T. nigra* of two generations combined in a mixed and runted breeding population has already been indicated by van Someren and Brown (1953), the formula $W = 0.033\ L^{2.744}$ being derived from these averages.

Owing to the faster growth of males, it is to be expected that their length/weight relationship would be different. In Figure 3, the curve for males in monosex culture has been derived from a variety of data from several monosex experiments at Sagana, the points being either averages of many fish in one pond, or in fewer cases, from individual fish.

The curve has been fitted by eye, and is compared in the same figure with a curve calculated from the formula for mixed

TABLE II.—GROWTH OF MALE AND FEMALE *T. mossambica* (ADAPTED FROM VAAS AND HOFSTEDE, 1952)

POND NO.	STOCKING	SIZE (CM.) AT		
		Stocking	1 month	2 months
11	24 ♂♂	5·6	11·6	14·5
10	24 ♂♂	6·0	12·1	14·9
13	24 ♀♀	5·7	11·1	13·9
14	12 ♂♂ + 12 ♀♀	♂5·6 ♀5·6	♂11·1 ♀9·7	♂14·2 ♀10·9
15	12 ♂♂ + 12 ♀♀	♂5·3 ♀5·8	♂11·3 ♀10·0	♂14·0 ♀11·1

NOTE.—All ponds 230 sq. metres in size.

breeding fish given above. A logarithmic transformation of the data for monosex males has enabled a calculation of the length/weigth formula to be made for these, and in this case $W = 0.018\ L^{2.994}$. This is in effect an expression of the fact that length for length, such monosex males are fatter and heavier than mixed breeding fish. Thus in monosex culture a 454 gm (1 lb.) male measures 29.5 cm., whereas in a mixed population this weight is not attained by an individual fish until it can reach a length of 32.0 cm.

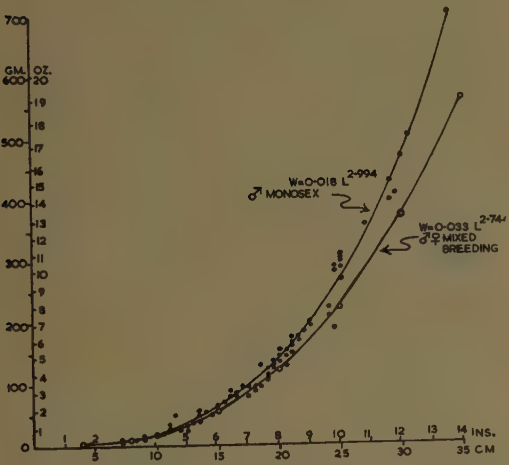

Fig. 3.—Length/weight relationships in *T. nigra*

The increase in weight of fish is logarithmically greater the longer they are, and in males the advantage is most marked from about 25 cm. onwards. The "maximum" growth fish detailed in Table I have in fact slightly exceeded the length/weight relation for males shown here. In this connexion however, it should be emphasised that this relation in Figure 3 expresses only a general average for males at Sagana which have not been subject to feeding or fertilization, and it could probably be influenced markedly by either of these practices, or varying the stocking rate greatly.

Nevertheless, a curve such as this has practical uses, for if the average lengths of fish in a pond are known, together with an approximate idea of the numbers of fish in the pond, an estimation of the standing weight crop at any one time is a matter of simple multiplication. Also if any two, or preferably three, points on the growth curve of the fish are known, it is also possible to forecast the total yield of that pond after a given length of time.

Calculated thus, there is no doubt that the yields of male fish under monosex culture, without feeding or fertilizing, do not anywhere approach the 3-4 tons of fish per acre claimed by Belgian workers for example. But by contrast, a yield of anything from 300-500 lb. of male fish per acre, every single one of which approaches the one pound mark, is in most cases preferable to a yield of several thousand pounds of fish most of which are of uneconomic trash size such as are found in all cases of heavy yields from mixed breeding fish.

There is also however, no question that growth rate and final weight achieved by male *T. nigra* can be increased by simple fertilization techniques, and direct feeding is also possible. The economics of these other techniques are at present under investigation, and results are so far promising.

SUMMARY

At equivalent stocking rates under comparable pond conditions, isolated male *Tilapia nigra* show a faster growth rate than isolated females. This sexual dimorphism in growth is probably genetically controlled, and is also characteristic of the closely related species *T. mossambica* and others of this group. This superiority in male growth is the basis of the monosex culture technique, and probably occurs under all conditions. Length for length, isolated males also show a greater weight per fish than do mixed breeding fish.

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(*a*) Pt. I. *E. Afr. agric. J., 25,* 42.
(*b*) Pt. II. *E. Afr. agric. J., 25,* 66.

CONTROL OF INFECTIOUS DISEASES OF ANIMALS: I

By Sir Thomas Dalling. Consultant of the Food and Agriculture Organization of the United Nations (F.A.O.), Rome, Italy

Although the words "infectious" and "contagious" when applied to disease are often thought to have the same meaning, there is a distinct difference. An infectious disease is actually caused by some specific agent and the condition set up by that agent is termed an "infection". If, now, that agent can be transmitted from the infected animal to other susceptible animals which, in their turn, develop the same condition, the disease produced is termed a "contagious" disease. In other words, all contagious diseases are infectious but all infectious diseases are not necessarily contagious. The diseases with which we shall deal in this and the next article are, in fact, both infectious and contagious, caused by what are popularly called "germs".

In the present article we shall discuss some of the diseases which are highly contagious, spreading rapidly and causing deaths of infected animals or lowered production or both.

We cannot do better than begin with *foot-and-mouth disease,* a disease whose name is familiar all over the world. The cause is a small particle of living matter called a virus which, in susceptible animals, is responsible for, among things, the obvious changes in the mouth and feet from which the disease is recognized. Other results of the infection, which are not so obvious, are found in the stomach (rumen) and the heart, those in the heart being sometimes responsible for the sudden death of the infected animal, maybe some considerable time after apparent recovery has taken place. All cloven-footed animals are susceptible to the infection. In some parts of the world foot-and-mouth disease is considered as probably the most important disease of livestock; in other countries, its occurrence is not generally regarded as a serious problem. There are reasons for these different views. In countries in which there is a relatively high concentration of livestock and where intensive production is the objective, the chances of spread of the infection are very great and there may be a heavy loss in production reflected not only in the finances of the individual farmer but in the economy of the country. It is estimated, for example, that the losses which arose from the 1951-52 epizootic in Europe amounted to at least 400,000,000 dollars. This loss represented mainly reduction in production during or subsequent to individual outbreaks or groups of outbreaks and the disruption of national and international trade in livestock and livestock products. In the less developed countries, very often the disease is milder in character and the results are not so disastrous: in many of these countries the disease is always present and is generally looked upon more as a nuisance, causing only some temporary inconveniences. This outlook, however, is not to be encouraged for, periodically, the mild disease gives place to an acute phase with heavier losses, especially from deaths of infected young stock; the development of an export trade in livestock and livestock products in such infected regions will continue to be much handicapped so long as foot-and-mouth disease is present.

Much progress is being made in controlling foot-and-mouth disease in some individual countries and the measures adopted by veterinary authorities, often as a result of assistance given by international organizations, is preventing the entrance of the infection into countries or groups of countries. While it is possible to apply a total out-and-out slaughter policy in some countries whereby any introduced infection is usually eradicated and the country is again free from the disease until a further introduction takes place, it is necessary in some countries, especially where the disease is endemic or where there is considerable exposure to the introduction of the infection, to carry out a vaccination campaign. The extent to which this is practised depends largely on circumstances and varies from annual vaccination of all or practically all the cattle population to vaccination of cattle in frontier areas and in prescribed districts following an outbreak. Vaccination is certainly playing an important part in controlling the disease in many countries. It is realized, however, that the objective behind vaccination is to reduce the incidence of the disease to such a low figure that a slaughter policy becomes economically possible. That stage is in sight in some countries and slaughter is being coupled with vaccination in others. Foot-and-mouth disease control by vaccination is made somewhat difficult because of the existence of different types of the causal virus, against each of which it is necessary to give protection by vaccination. For a long time three distinctly different types of the virus were recognized in most infected countries throughout the world: four further types have now been shown to exist, three of which are at present confined to Africa and one to Asia. Again, some variations have been shown to exist in each of the originally known three types, necessitating the development of vaccines for use against them. Many of the difficulties in the preparation and production of foot-and-mouth disease vaccines are being overcome. New techniques are being used and it is probably only a matter of time until the old methods of preparation are replaced. Vaccines, as presently used, give good results and the disease can be rapidly controlled and spread prevented by vaccination. In countries in which regular vaccination is carried out, suitable vaccines for protection against the types of the virus most likely to be present in, or to be introduced into, the country are used. It is always necessary to ascertain the type of the virus in any new outbreak whether or not a vaccination policy is being practised: this is done in laboratories which are equipped for this work. Such laboratories exist in several countries in different parts of the world: for special work on typing of the virus and for assisting countries, especially in Africa and Asia, in determining the types causing outbreaks, the Research Institute (Animal Viruses), Pirbright, England, is now recognized as the world foot-and-mouth-disease reference laboratory. Vaccination is carried out almost entirely in cattle: there has still to be elaborated a more efficient product for the protection of pigs, in which foot-and-mouth disease may cause much damage and from which the disease often spreads to cattle. In addition to a slaughter policy or vaccination, it is highly important in preventing the spread of the infection that early reporting of outbreaks takes place, that severe restrictions on the movements of animals in an infected area are imposed and that careful and thorough disinfection of infected premises is carried out before susceptible animals are again introduced.

While the distribution of the seven different types of the virus is fairly well known today, their appearance in new areas is being carefully watched so that measures for the prevention of their spread can receive attention. It is generally agreed that the eradication of foot-and-mouth disease demands both national and international action. A beginning has been made to eradicate the disease from the whole of Europe through the establishment of the European Commission for the Control of Foot-and-Mouth Disease. The intention is, eventually, to extend international control and eradication plans to other regions and, finally, at some stage to link up their activities and so cover as much of the world as possible.

At one time it was considered that *rinderpest* (cattle plague) was probably the most important contagious disease of livestock, mainly because of the high mortality among infected animals. Although the disease has been widespread in different parts of the world, it is now confined to certain regions of Africa and Asia and, even there, it is gradually being brought under control although severe outbreaks periodically occur. The high mortality mades rinderpest a more spectacular disease than some others in which the losses, apart from actual deaths, may be very high. Strict measures against its introduction are taken by the veterinary authorities in countries which have always been free or from which the disease has been eradicated.

Immunizing of susceptible animals against the infection is now practised on an extensive scale in infected countries by the use of suitable vaccines. Fortunately, as opposed to foot-and-mouth disease, there is no evidence that more than one type of the causal virus exists: this means that the production of satisfactory vaccines is simpler. The actual vaccines now in use differ markedly from those available in the earlier days of rinderpest control. The introduction of new methods of virus-vaccine preparation have resulted in the production of products which can be stored under suitable conditions for long periods, ready to be used when required. This stage has not yet been reached in foot-and-mouth disease vaccine production. Vaccines now in use in the control of rinderpest consist mostly of the living virus in an attenuated or feebly virulent form, attained by passing the virulent virus through a species of animal of low susceptibility, e.g. goats or rabbits, or through the developing chick in fertile eggs. Susceptible animals, e.g. cattle and buffaloes, receiving a single dose of such a vaccine are rendered immune to natural infection for long periods, probably for several years or even for life. This finding simplifies the work in operating vaccination campaigns for the control of the disease. At the beginning of a campaign all adult susceptible cattle and buffaloes, in a satisfactory state of health, receive a dose of vaccine: these animals should not require any further vaccination. Periodically, vaccination is again carried out in the area when any animal not already vaccinated is dealt with. This includes animals which were considered too young to be treated on a former occasion or have been born since the others were vaccinated.

Campaigns for the control of rinderpest differ from those against foot-and-mouth disease, for a serviceable immunity induced by the vaccines at present in use for the latter disease is of relatively short duration and injections have to be repeated at intervals of a few months and certainly once a year. In India today, a carefully planned vaccination campaign for the control of rinderpest is being successfully operated throughout the whole of the subcontinent. A few years ago a concentrated effort by the veterinary authorities in Thailand eradicated rinderpest from the whole of the country. Except for some occasional introductions, which have been dealt with successfully, the country has remained free from the disease. These examples illustrate the adoption of measures by individual countries: while they prove successful in controlling and even eradicating the disease in a specified area, there is need for international collaborative effort finally to clear rinderpest from all parts of the world.

It has been found that the degree of attenuation, i.e. reduced virulence of the virus in a vaccine, must vary according to the susceptibility of the animals to be treated. This has been provided for and vaccines are now available for use in countries and regions where even the most highly susceptible cattle and buffaloes are present.

The occurrence of rinderpest in wild ruminants will probably remain as a source of infection in some parts of the world so that vaccination campaigns will still be needed.

The presence of rinderpest is preventing, to a considerable extent, the development of an export trade in livestock and products of animal origin in some parts of the world. It must be expected that countries free from the disease will continue to refuse such imports, so long as rinderpest is present in the exporting country or until scientific evidence shows the conditions under which there would be no risk of introducing the causal virus from such infected countries.

Another example of a contagious disease, at one time prevalent in many parts of the world and now confined to some specified areas, is *contagious bovine pleuro-pneumonia.* Even before modern methods of control became available, the disease was eradicated from several regions by veterinary activities, and precautions taken to prevent its reintroduction have proved entirely successful. Today, contagious bovine pleuro-pneumonia occurs in some of the northern, eastern, western and central parts of Africa, in Australia where it is endemic in the northern area with sporadic outbreaks in southern districts associated with the movement of infected cattle, in Assam (India) and in a few European countries in which it is being satisfactorily controlled and eradication is in sight.

While the presence of the infection in an acute form in a group of cattle may cause a high mortality, the most dangerous animals causing spread are those which have recovered and become "carriers" of the disease. In such animals the affected portion of the lungs become sealed off and may remain in this condition for long periods: these lung areas, however, still contain the virulent causal microorganism and, following a lowering of the vitality of the animal due to any form of stress such as long journeys and periods of drought, a "breakdown" occurs and the infection spreads to susceptible animals.

Clinical examination of acutely infected animals usually detects the disease; the postmortem appearance of affected lungs is very typical of the infection. In examining a group of animals among which the infection is present, all of which may not show the typical clinical picture, it is necessary to make use of laboratory tests in which the serum of the blood is used.

Contagious bovine pleuro-pneumonia can be prevented to a great extent in infected areas by vaccination of susceptible animals. A considerable amount of research work on the production of vaccines has been carried out and is still in progress in the different infected countries. For many years a living culture of the causal organism inoculated into the tail has been used in Australia, with good results: many vaccinated animals are capable of resisting infection within a few days and remain in a protected state for at least three years. A very small number of excessive tail reactions are reported and their occurrence in vaccinated calves may be followed by heart and joint complications. Other types of vaccine being studied in different countries include those containing the causal agent in different stages of attenuation, cultivated in the developing chick embryo and the causal agent treated by chemical agents to which an adjuvant is added. In controlling the disease, it must be recognized that spread takes place from already infected animals and that their movement into non-infected areas is the important source of new infections.

Pleuro-pneumonia in goats and sometimes in sheep causes much loss in some parts of the world: the cause, however, is probably quite different from that of the disease in cattle.

Members of the pasteurella group of micro-organisms are the causal agents of, or are associated with, some diseases of animals and birds. The group contains several types of pasteurellae and some may cause specific diseases. Such a disease is *haemorrhagic septicaemia* (barbone) of bovines which occurs especially during and after the rainy season in some tropical and semi-tropical parts of Asia and Africa. The name "haemorrhagic septicaemia" is sometimes loosely used with reference to other diseases, the causal agents of which may yet have to be defined: with some of them, pasteurellae may be associated, probably in the role of secondary infectors. It has now been shown that the "haemorrhagic septicaemia" or "barbone" is, almost certainly, caused by one type, and one type only, of a pasteurella (*Pasteurella multocida*—Roberts type I).

Unless immunization of susceptible cattle and buffaloes is carried out in infected areas, there may be a high mortality from the disease: the occurrence of the disease often coincides with the time when the animals are much required for land cultivation purposes. The type of vaccine mostly used has been a chemically-treated liquid culture of pasteurellae isolated from infected animals. While such vaccine gives some beneficial results, the degree of immunity induced is relatively low and of such short duration that, in some districts, it has been necessary to repeat vaccination during the season of the infection. Recent research work has resulted in the production of vaccines which give better immunity for a longer period. It has been shown that the immunizing substance is contained in the capsule which surrounds the causal pasteurella. This capsule is largely destroyed during artificial cultivation of the micro-organism: it is necessary, therefore, that very young cultures are used for the production of vaccine. Again, the pasteurella loses its immunizing value if it is subjected to a series of subcultivations; hence, strains of the micro-organisms very recently isolated from infected animals are necessary. The mixture of these cultures with an adjuvant has been shown to be of much importance in the preparation of an efficient vaccine and good results are reported following the injection of vaccines prepared by methods which make use of such discoveries. Modern vaccines for use in the control of haemorrhagic septicaemia meet the necessary requirements, viz., they can be produced in bulk; they are easy to administer; they do not produce undesirable reactions; they produce immunity of sufficiently high order and duration to protect susceptible animals for the required period. Vaccination campaigns should not be difficult to arrange because the time of the annual occurrence of the disease is usually known within limits.

While there are many diseases of poultry of considerable economic importance in most countries, that which has caused greatest loss to the industry is probably *Newcastle disease* (Ranikhet disease). There are few parts of the world, where poultry are kept on an extensive scale, free from this virus infection. At one time it was thought that the disease existed only in an acute form from which practically all infected birds died. We know now that there is a much milder type in some areas, causing losses through lowered egg production and interference with the general health of poultry. Although this latter type of the disease may not be accompanied by many deaths in a flock, periodically the acute form appears in infected flocks with disastrous results. The modern methods of intensive poultry husbandry favour rapid spread of the infection. Reliable laboratory tests for which samples of blood are used are now available for the detection of the disease, including the milder forms.

Much study has been made of the control of Newcastle disease. In some countries a slaughter policy is practised: all the fowls in an infected flock are destroyed and burned or buried and the premises are thoroughly disinfected before restocking is permitted. For economic reasons this method cannot be carried out today in many parts of the world. There are, however, vaccines which give satisfactory immunity against the infection. Although different vaccines are in use in different countries and the methods of their application vary, the best results appear to be obtained from vaccines composed of the living causal virus, the virulence of which is such that it does not cause infection in susceptible fowls. The causal virus used as a vaccine is now usually cultivated in developing chick embryos. Very young chicks may become infected and high mortality among them may occur. They may be protected to a considerable extent by the satisfactory immunization of the breeding fowls, the fertile eggs from which contain protective antibodies which are passed on to the chick in the egg. Such immunity, however, is of comparatively short duration, continuing at an adequate level for only a relatively short time; further immunization of such chicks at a few weeks of age becomes necessary. Some recent work has shown that very young susceptible chicks may also be protected by the use of a vaccine prepared from a strain of the virus found in England in a naturally attenuated condition. Here again the immunity is of short duration and further immunization is required at a later date. The virus-vaccine may be applied, especially in young chicks, by inhalation, through depositing it on nasal openings; it may also be dropped into the conjuctival sac of the eye. In older fowls, a more potent type of vaccine is often given into the wing web. Experience has shown that, using vaccine prepared from the above-mentioned naturally attenuated strain of virus simultaneously with a vaccine prepared from a mild strain of the virus which causes fowl pox, young chicks may be protected at the same time temporarily against both Newcastle disease and fowl pox.

The sheep industry in all parts of the world suffers economic losses from diseases in the flocks, one of the most important being blue tongue, which was first recognized in southern Africa and more recently diagnosed in other parts of Africa, in some Near East countries, in some parts of the United States of America and in Portugal and Spain. The disease, caused by a virus with considerable powers of resistance, may spread rapidly within a given area, causing a mortality of about 10 per cent in most outbreaks although the death rate may vary between 2 and 80 per cent. Much research work has been carried out on blue tongue, especially in South Africa, but there are still some important problems awaiting solution.

Field evidence indicates that the causal virus may be insect-transmitted and that sheep exposed to species of culicoides (midges), especially in low-lying moist districts at night in the infected areas, contract the infection. Outbreaks occur only during the late summer months but it does not follow that sheep will become infected even when large numbers of midges may be present under conditions considered good for transmission. This may be because the midges do not carry the virus from one season to another and that the true reservoirs of the infection, at present unknown, are not present.

There is not yet exact information on the spread of the disease into non-infected areas or countries. It is known from experimental work that sheep which have recovered from the infection may continue to harbour the causal virus in a much reduced state of virulence for some weeks (120 days). Such recovered sheep may, therefore, continue to be a cause of residual infection.

MUTTON BREEDS MORE SUSCEPTIBLE

Blue tongue is essentially a disease of sheep, all breeds being susceptible, but mutton breeds more than Merinos. Variations of individual susceptibility occur within a breed. Cattle are also susceptible but to a lesser degree. Affected cattle have been found in Israel and the infected European countries. It may be that the absence of the clinical disease in cattle in South Africa arises because of the exposure to the infection of the young animals when they are in a protected state from the passive immunity derived from their dams. Although cattle may show little or no clinical evidence of the infection, they can, nevertheless, harbour the causal virus. There is evidence from experiments that the virus may be present for up to 70 days following artificial infection. It is also known that wild rodents may carry the infection.

SYMPTOMS OF THE DISEASE

Blue tongue is characterized by a high temperature lasting from a few days to over a week, by reddening of the membranes of the mouth and nose, by discharge from the nose, by swelling of the lips, tongue and the space between the branches of the lower jaw, by peeling of the top layers of the skin of the lips and nostrils, by a general reddening of the skin, interfering with the nutrition of the wool and so causing breaks in the wool, sometimes by inflammation of some of the structures of the feet and by loss of bodily condition: affected lambs may show diarrhoea.

There seems to be little doubt that blue tongue is insect-transmitted but information on the reservoirs of the causal virus is still lacking. As it is impossible yet to eradicate the transmitting insects, prevention of the disease must consist in the annual mass vaccination of susceptible animals. From time to time different types of vaccine have been produced. The type now in general use is a vaccine consisting of four different strains of the virus whose virulence has been much reduced by passage through developing chick embryos: it is produced in a freeze-dried form and can, therefore, be kept for long periods under suitable conditions. This vaccine is giving generally satisfactory results: it is cheap, easily prepared, easily transported and safe to use except, perhaps, in ewes vaccinated for the first time during pregnancy, from a small number of which there is some evidence from America that abnormal lambs were born. Although, on the whole, this vaccine gives satisfactory results, a disadvantage is that, because so many strains of the virus are used in its preparation, a high immunity against all of them may not be established.

Swine Fever or Hog Cholera

In pigs, the disease which causes the greatest economic losses, generally speaking, is probably swine fever (hog cholera). It is found in most parts of the world where pigs are kept. The incidence varies from country to country: in some, the disease is endemic and, in spite of the efforts to control and eradicate the infection, repeated outbreaks occur, often associated with the movement of pigs. Some countries, which raise pigs on an extensive scale, have remained free from swine fever; this, to a large degree, is due to the prohibition of importation of pigs and pig products from other countries. It is well known that such importations, especially of pig products, have introduced the disease into countries which were free from the infection. The application of severe veterinary measures, following early recognition of the disease, have eradicated the infection in some of these countries.

Methods of Combatting the Disease

Undoubtedly, the most satisfactory results following the appearance of the disease in a country are obtained from a slaughter policy with restrictions of movement, the destruction of carcases of the slaughtered animals and careful disinfection of infected premises. By adopting such a system a country can, usually within a reasonable time, be freed from the infection. In countries in which the disease is endemic, however, a slaughter policy is usually impracticable, although the restriction of movement of pigs out of or into prescribed infected areas will prevent spread to other areas. The application of regulations for the cooking of all garbage (swill) has also a considerable value in preventing spread of the disease.

In countries in which swine fever is endemic, vaccination is usually practised, sometimes on an extensive scale. The simultaneous infection of the living causal virus and protective serum was used for many years and, although effective in controlling the disease, was not entirely satisfactory because some pigs became ill within a few days and breaks in the immunity were sometimes found after a few months. These occurrences were seen in spite of strict control of the potencies of the virus and serum. Extensive research in the United States of America has shown that these losses were due, probably, to the development of variants of the virus which were not affected by the serum.

Other types of immunizing agents against swine fever have become available: there is the vaccine consisting of the virus exposed to the dye, crystal violet; and the vaccine containing the virus attenuated by passage through rabbits, used alone or simultaneously with protective serum. In general, these vaccines are giving favourable results; but unsatisfactory results, which are seldom found, are the subject of study at the present time.

African Swine Fever

It is to be noted that the disease named African swine fever which, as its name implies, occurs in parts of Africa, is not the swine fever which occurs in other parts of the world. The causal agents are different and the protection against swine fever as carried out in many countries does not protect against the African disease. The African disease appeared recently in Portugal and was eradicated by the adoption of a slaughter policy.

All the diseases already discussed in these articles are, generally speaking, diseases of animals and not normally of human beings. There is some evidence that the viruses of foot-and-mouth disease and Newcastle disease have caused some localized human disease, usually very mild in character and quickly responding to treatment. There are, however, a number of infectious diseases of animals which also cause serious diseases in man. In this article, two are discussed.

Bovine Tuberculosis

Bovine tuberculosis in cattle is responsible for considerable losses in production throughout the world where demands are made for high production in cattle and where husbandry methods favour the spread of the infective causal agent. In some of the less developed countries, and in regions where cattle are mostly on wide, free range, the incidence of the disease may be very small, but where milk production on intensive lines is carried out, bovine tuberculosis may exist to a marked extent. The freedom or comparative freedom of some regions from bovine tuberculosis is maintained to a considerable extent by the precautions taken to prevent its introduction. In considering bovine tuberculosis we must also remember that it is a disease of human beings, occurring mostly in children and adolescents. The causal agent is conveyed mostly by the consumption of products, especially milk, derived from tuberculous animals, as well as contact with infected livestock. Infected animals other than cattle may sometimes cause the disease in human beings. Monkeys, dogs, cats and pigs are all susceptible to bovine tuberculosis and may transmit the infection.

INFECTION MEANS LOWER MILK YIELD

In view of the damage done by the disease, much attention has been given to its eradication not only from herds of cattle but also from whole countries. Some countries have been freed from the disease in the cattle: some will soon be free, while in others rapid progress is being made in the eradication of the infection. It has been shown, repeatedly, that higher production results from herds free from bovine tuberculosis, the lower production in infected herds being not only due to the direct effects but also to the indirect effect of the disease in opening the way for other diseases.

Some earlier attempts to control bovine tuberculosis in herds did not always prove entirely successful. The essentials in controlling and eradicating the disease are to discover the infected animals, to remove them at once from all contact with the other stock, to disinfect the premises occupied by them and to ensure that no further infection is introduced into the herd. While there may be a variety of ways in which the causal organism may enter a herd, the most important is the infected bovine, especially the animal which, so far as the eye can judge, is healthy. The disease may be present in some organ or tissue of the animal, even for long periods during which no outward signs are obvious. This is the dangerous animal because, quite suddenly, the infection in its quiescent form may become active and spread rapidly throughout the herd, even before any marked evidence of the disease is seen in the originally infected animal. Unfortunately, this animal is quite often a high producer and the owner fails to appreciate the harm which it may be doing. Such an animal also constitutes a danger to human beings.

TUBERCULIN TEST IS SAFEST CHECK

An acutely infected animal, with obvious signs of ill-health, may be diagnosed as suffering from bovine tuberculosis by the recognition of the causal agent in its bodily secretions or excretions, e.g. milk, sputum and faeces. Diagnosis by this method is not always satisfactory, because the causal micro-organisms may not regularly appear: it cannot be applied to the type of animal in which the lesion containing the active agents, but not excreting them, is temporarily sealed off. The only satisfactory diagnosis of bovine tuberculosis today is the application of the tuberculin test, especially by the intradermal method: there are few infected animals which fail to react to the test.

Tuberculin, produced from *M. tuberculosis*, has long been used in the diagnosis of tuberculosis in animals, but the type of tuberculin, the methods of its application and the interpretation of the results have changed over the years. Most of the tuberculin in use today is a purified form which consists very largely of tuberculo-protein, produced during the artificial culture of the organism. The site of the injection of tuberculin is also varied; in some countries the neck is used, while in others the injection is made into the fold of skin at the top of the tail—the caudal fold. A difficulty in the use of tuberculin is the sensitivity of animals in which infections other than true bovine tuberculosis exist; this also causes reactions to some types of tuberculin. Most of the tuberculins in use are derived from mammalian strains of *M. tuberculosis*, sometimes the true bovine strain, sometimes the human strain, sometimes a mixture of both strains. Tuberculins from these strains produce reactions not only in animals suffering from bovine tuberculosis but also in animals with other sensitivities caused e.g. by the avian strain of *M. tuberculosis*, by the causal agent of Johne's disease and by the micro-organisms which give rise to so-called "skin tuberculosis". The result is that, in the application of tuberculin of mammalian origin, an animal suffering from any of these infections may react positively. This difficulty can be overcome to a large extent by the use of two tuberculins simultaneously—one of mammalian origin and one of avian origin. Reactions to both tuberculins will be found in most animals with any of these infections, but the difference in the reactions as shown by their character and size assists in the determination of the presence or absence of bovine tuberculosis. The tuberculin test should be regarded as a herd test rather than as a test applied to an individual animal and the health history of a herd is of much value in the interpretation of the results of tuberculin tests.

Herd Tests Should be Repeated

In the eradication of bovine tuberculosis, the removal of animals reacting to tuberculin is essential, together with disinfection of the premises. It is also necessary to continue tuberculin testing at stated intervals in the remaining non-reacting animals in order to detect those in which the duration of the infection had not been sufficiently long to ensure their sensitivity at the former test. It may be necessary to repeat the tuberculin test in a herd a number of times until no reactors are found at two successive tests: it is only then that the herd may be accepted as free from bovine tuberculosis. Ideally, the disposal of reactors should be by slaughter and this is the system in some countries. It has been demonstrated, however, that, with the application of satisfactory precautions against the introduction of the infection, herds can be maintained free from the disease, although there are infected herds in the surrounding area.

Cattle Owners Encouraged to Co-operate

The eradication of bovine tuberculosis from a country may begin by consideration of individual herds but, soon, the plan must concern areas until the whole country is covered. Cattle owners are usually encouraged to co-operate in any eradication scheme by the award of bonuses for milk from herds free from the disease or by an annual capitation grant: these are usually made available for a specified number of years.

Vaccination of cattle against bovine tuberculosis has been fully considered. While vaccines are used in human beings and while experiments show that they also set up resistance to bovine tuberculosis in cattle, the many difficulties encountered in their application to cattle have resulted in a general veterinary opinion against their use.

Domestic animals, other than cattle, suffer from bovine tuberculosis. Swine, for example, are quite susceptible, and in some countries the disease in them is extensive. Swine also suffer from avian and human tuberculosis and, in the application of tuberculin tests, it is always necessary, as it is sometimes in cattle, to use tuberculin of mammalian and avian origins. The possibility of the transmission of bovine tuberculosis from swine has to be considered when eradicating the disease from an individual cattle herd, an area or a country.

May be Confused with Other Diseases

While, usually, the clinical picture of the disease is sufficient for recognizing its presence, even the advanced disease may be confused with other conditions, especially internal parasitism. Microscopic examination of scrapings from the intestinal lesions may show the causal organism in infected animals, but the absence of the bacillus is not to be regarded as freedom from the infection, especially in animals in which the clinical symptoms have not yet developed to a marked extent. Other methods of testing for the presence of the disease have been the subject of study. The product, johnin, prepared by the cultivation of the causal organism in special liquid medium, is sometimes used for diagnosis, especially in the early stages of the disease. It is usually injected intradermally. Avian tuberculin is also sometimes used for diagnosis, injected intradermally, and causes a local reaction similar to that produced by johnin. Although these products are useful in some cases, they are not entirely reliable. Serological tests have also been studied and are said to be particularly useful for diagnosis, especially in infected animals over a year old.

Bearing in mind that large numbers of the bacilli are excreted in the faeces of infected animals and that young animals are particularly susceptible to the disease, methods of control should include the early detection and removal of infected animals and the early separation of the calf from its dam so that it may be reared out of contact with the infection.

Immunizing Susceptible Animals

Some work has been carried out in immunizing susceptible animals with vaccine containing the live virulent organisms incorporated in an excipient composed of mineral oil and finely ground limestone. It is injected into young animals which are negative to johnin and avian tuberculin tests. The injection produces a hard swelling which may persist for some years. There is evidence that vaccination is useful in heavily infected herds. Although the effects of a single injection of the vaccine may continue for some years, it is considered advisable to repeat vaccination every 15 months or even at shorter intervals. Treated animals become sensitive to tuberculin. This may cause some difficulty in the interpretation of results of the tuberculin test in treated herds. The use of the comparative tuberculin test, however, is of much assistance in determining the significance of the reactions.

From evidence collected in various countries, it is becoming apparent that Johne's disease is more prevalent throughout the world than was formerly appreciated. The need for the careful veterinary examination of all imported animals for the detection of this and other diseases must be stressed.

Three Strains of Brucellosis

Brucellosis is another highly contagious disease of cattle and other animals, transmissible to human beings. There are three more or less distinct strains of the causal agent—*Brucella abortus. Br. melitensis* and *Br. suis*, all of which may infect domestic animals on occasion although it is generally recognized that brucellosis is caused by *Br. abortus, Br. melitensis*, and *Br. suis* in cattle, in sheep and goats and in swine, respectively. Abortion is often a symptom of brucellosis, hence the commonly-used term "contagious abortion" in cattle. Many infected females, however, do not abort, especially when the disease has been present in a herd for some years and the infection may be present in male animals. The only way to diagnose the disease is by the recovery of the causal organisms from the aborted calf, the foetal membranes or the discharges from the genital tract, or from the milk. The use of the agglutination test is also very valuable. In the absence of measures to control and eradicate *Br. abortus*, the disease may persist in the herd, resulting in an occasional abortion and irregular and difficult breeding. It may also happen, especially if susceptible breeding cattle are introduced into the herd, that the disease again becomes acute and a typical "abortion storm" results. The infection is easily conveyed to non-infected females by the discharges from the genital tract of infected animals, and even through their milk. While *Br. abortus* continues to be excreted from the infected genital tract until all discharges following abortion or calving have disappeared, the organism may still be found in the milk at irregular intervals over a long period.

The control and eradication of brucellosis in cattle may be accomplished in two ways. One is similar to the procedure for eradication of bovine tuberculosis, viz., the diagnosis and removal of infected animals, together with thorough disinfection and the prevention of further introduction of the disease. The infection has been eradicated from many herds by these measures; but, because of the ease with which the causal organism can be conveyed, considerable difficulties have been experienced in maintaining herds in a state of freedom.

Immunity ,Lasts for Some Years

The other method is the protection of animals by vaccination. This has been practised for many years, using vaccines prepared in different ways. It has been clearly shown that vaccines must consist of living *Br. abortus* so attenuated or reduced in virulence that their injection does not set up the disease. The most universally used vaccines at the present time consist of such organisms as the well-known Strain 19, discovered in the United States of America in a naturally attenuated form. This organism has been shown, by carefully controlled experiments, to retain its state of attenuation after having been passed through many cows and thus its safety for use as a vaccine is ensured. The injection of a single dose of this vaccine into non-pregnant cattle sets up a relatively high state of immunity lasting for some years.

Vaccination at a young age renders animals resistant to the infection during the period of high susceptibility and lasts at least until a natural resistance develops with age. To obtain maximum results, the vaccine must be prepared by a process which is now well known throughout the world. Recent work has resulted in the preparation of this vaccine in a freeze-dried condition which means that, under satisfactory conditions of storage, it can be kept in a living and active condition over long periods. While the protection against infection is high, it may not always be absolute and "breaks" do sometimes occur. It is seldom, however, that an animal which has received potent vaccine at a suitable age, aborts even though some degree of infection may be present. The wide-scale use of the vaccine has been followed by a marked reduction in the incidence of brucellosis and this has lead to the study of causes of abortion other than *Br. abortus*. A disadvantage of some importance with the use of the vaccine is the development of agglutinating substances in the blood of infected animals, so they may react to the agglutination test. This is of little consequence in many herds, for the object of the vaccination is to prevent the disease. On the other hand, in some cattle, particularly those for export, negative reactions to the agglutination test are required.

AGE AT VACCINATION IS IMPORTANT

In considering such agglutination reactions, the age at which vaccine is injected is of importance; the older the animal, the more do agglutination bodies tend to persist. The normal practice is to vaccinate calves, female and male, between the ages of four and eight months. Animals vaccinated at a younger age will probably fail to be protected in later life because the mechanism for the production of protective antibodies will not have developed to the extent of being stimulated by the vaccine. Most of the heifers vaccinated between these ages will react negatively or only at "low titre" to the agglutination test by the time they reach breeding age. In non-vaccinated animals, a "low titre", however, may indicate the beginning of a natural infection. The significance of such a titre may be clarified if it is known that the animal was vaccinated at a certain age and that, just before vaccination, the blood agglutination test was negative.

Brucellosis of sheep and goats presents an important problem in some regions. It is commonly found in North African countries, some parts of East, West and South Africa, some European countries, especially in southern parts of the continent, some Near East countries, in south-east Asia, in Mexico and in some States of the United States of America and in South American countries. In addition to the losses in animals, the disease also causes "undulant fever" in human beings. Infection occurs by handling infected animals and by consuming products, especially milk or unripened soft cheese, prepared from milk from infected goats and sheep. Within recent years, much research work has been carried out on brucellosis in sheep and goats. More is now known about the stages of infection at which *Br. molitensis* is excreted and about the persistence of the organism in the animal body.

NEW VACCINES BEING PRODUCED

Considerable progress has been made in the preparation and evaluation of different vaccines for the prevention of the infection. Work in the laboratory and with small numbers of sheep and goats has shown that at least two vaccines are satisfactory immunizing agents. We must now await the results of large-scale field trials of these vaccines before one or both can be recommended for general use. Much of the work on testing the value of the vaccine was done in Tunisia through technical assistance provided mainly by the Food and Agriculture Organization of the United Nations.

The characteristics of the three classical types of brucella, as shown by laboratory tests, have been recognized for a long time. There is now evidence that there exist brucella which do not correspond exactly to any of the three. "Intermediate types" have been found. One such has been recovered from a few milking cows in England: it shows some of the characteristics of *Br. abortus* and some of *Br. melitensis,* and was originally found in the milk. This finding led to the enactment of the Brucella Melitensis Order of 1940 which, among other things, provides for the slaughter of cows in which this organism is found. In spite of its presence in the milk of infected cows, there is no evidence whatsoever that any infection of human beings, handling or drinking milk, has ever occurred.

HARES MAY BE "RESERVOIRS" OF INFECTION

Br. suis infection is found mainly in some European countries, in some Asian countries, often only in imported swine, and in parts of the Americas. Many countries are entirely free, doubtless either because no swine are imported or because very strict precautions are observed. In many of the infected countries the incidence of the infection is being reduced. A characteristic of the disease, at least in some European countries, is that outbreaks occur sporadically, without any apparent introduction of the infection into a swine breeding herd. In this connexion, the infection has been found in hares and it is very likely that these animals act as reservoirs of the infection which gains entrance, periodically, to herds of swine.

Up to the present time, no satisfactory vaccine has been developed for the prevention of the disease. The only control method, admittedly not entirely satisfactory, is the diagnosis of the infected animals by the blood agglutination test and their removal from the herd and, preferably, slaughter and the careful disinfection of premises. Testing has to be continued until no further reactors are found. The boar must be included in the tests because of the part played by the male in the transmission and spread of the causal agent.

EXPERIMENTS ON THE CONTROL OF STALK BORERS ON SORGHUM IN UGANDA

By W. R. Ingram. Department of Agriculture, Uganda

(Received for publication on 24th July, 1959)

Large acreages of sorghum are grown all over Uganda and particularly in Northern and Eastern Provinces. This sorghum is always attacked to some extent by stalk borers and, though while under good growing conditions they are not considered to be of economic importance (Ingram, 1958), it was felt that experiments on their control should be carried out to try to increase the yield.

While successful control methods were known against *Busseola fusca* (Fuller) in Kenya (Jepson, 1954), in Tanganyika (Swaine, 1957) and in South Africa (Taylor, 1952) it was felt that the Uganda complex might need more elaborate control methods. Indeed Coaker (1956), working on maize in Buganda Province, obtained fairly satisfactory control but no increases in yield. This Uganda complex consists of many stalk borers the more important being *B. fusca*, *Sesamia calamistis* Hampson (both Noctuidae) and *Chilo zonellus* (Swinhoe), Pyralidae.

B. fusca spends the dry season in diapause as a late instar larva and pupates shortly after the commencement of the rainy reason. This leads to an emergence of adults which oviposit on the crop at an early stage of its growth. Two to two and a half generations occur in the crop and the third generation attacks the second rains plantings. *C. zonellus* and *S. calamistis*, however, have no resting stage and are continually flying in from their dry season hosts and attacking the crop. Thus *B. fusca* can be controlled with two or three well timed applications of insecticide to coincide with the hatching of the eggs but the two other species need far more frequent applications to obtain any measure of control.

The results of three trials conducted on sorghum at Serere Experiment Station in Eastern Province are given here. Two similar trials were carried out in 1956 whilst the third trial, based on the results of the first two, was carried out in 1958.

THE 1956 EXPERIMENTS

These trials compared ten treatments in randomized blocks with four replications. The sorghum was mechanically planted in 28 inch rows across 35 yard strips, the rows being thinned to about 12 inches between each plant. The plots consisted of 17 rows of 50 plants each. The two outside rows were discarded as guard rows and guards were left at the end of each row. The remaining 15 rows were divided into five subplots of three rows each, estimations of borer damage were taken from these subplots by removing the centre row. The sampling dates were randomized within the five subplots.

This sample is open to criticism in that it may not be a representative sample of insect attack in the whole plot at that time but it was considered sufficient and could readily be understood by unskilled staff. It was also used to show the effect of thinning out entire rows at various stages of the crop's growth.

The first sample was taken the day before treatments commenced and was intended to show if there was any variation in attack. The second, third and fourth samples were taken at fortnightly intervals from this date (sample four actually being at the beginning of flowering) and the fifth sample at harvest.

Counts included the numbers and heights of the tillers, the numbers of dead hearts (caused by the shoot flies *Atherigona indica infuscata* Emd. (Muscidae) and *Scoliophthalmus micantipennis* Duda (Chloropidae)) and the numbers of bored tillers. It was assumed that all *Sesamia* larvae were those of *S. calamistis* as this is by far the most common species while the larvae of *B. fusca* and *C. zonellus* could readily be determined.

The treatments commenced immediately after the fields had been thinned when the plants were about six inches high. Thus all very early pest damage, mainly shoot fly, was eliminated. The treatments were as follows:—

(*a*) Five weekly applications of 0.0126 g. active ingredient of D.D.T. per funnel as a dust.

(*b*) Three fortnightly applications of 0.0126 g. a. ingr. of D.D.T. per funnel as a dust.

(*c*) Five weekly applications of 0.0252 g. a. ingr. of D.D.T. per funnel as a dust.

(*d*) Three fortnightly applications of 0.0252 g. a. ingr. of D.D.T. per funnel as a dust.

(*e*) Five weekly applications of 0.0252 g. a. ingr. of D.D.T. per funnel as a miscible liquid.

(*f*) Three fortnightly applications of 0.0252 g. a. ingr. of D.D.T. per funnel as a miscible liquid.

(*g*) Five weekly applications of 0.0063 g. a. ingr. of D.D.T. per funnel as a miscible liquid.

(*h*) Three fortnightly applications of 0.0063 g. a. ingr. of D.D.T. per funnel as a miscible liquid.

(*i*) Weekly applications of 0.0252 g. a. ingr. of dieldrin per tiller in an emulsion as an overall spray—"blanket" treatment.

(*j*) Control—nil treatment.

Dosages are given per funnel as Uganda sorghum varieties tiller fairly heavily and although the rate of 0.0252 g. per funnel is equivalent to one pound of active ingredient per acre at the beginning of the experiment, the rate per acre gradually rose as the number of tillers increased.

The D.D.T. dusts were applied with home-made "pepper-pot" shakers drilled so that at each shake approximately the right amount of dust came out. The D.D.T. miscible liquid was poured direct into the funnel using a tot measure on a bottle and the dieldrin was sprayed on with a knapsack sprayer.

The first trial was laid down in April at the beginning of the first rains. The shoot fly attack was very light and at the beginning of flowering, i.e. after the D.D.T. treatments had ceased, there were still no stalk borers. However, the experiment was continued through to harvest when the borer population was still negligible but it was found that the dieldrin blanket spray had caused a significant depression of the yield. It was, therefore, decided to reduce the dosage to 0.0126 g. per tiller—½ lb. per acre equivalent—in the next trial.

The second trial was laid down in exactly the same way in August. The first sample showed that there was a slight, uniform attack of borer all over the field before the treatments began. Sample 2, a fortnight later when two weekly and one fortnightly treatments had been applied, showed slight differences between some of the treatments in the numbers of bored tillers, but these were not significant (*see* Table 1). There were no differences in the shoot fly dead-heart count.

TABLE 1

TREATMENT	MEAN BORED TILLERS				YIELD lb./acre
	Sample 2	Sample 3	Sample 4	Sample 5	
(*a*) 0·0126 g. D.D.T. dust weekly	1·5	3·0	6·0	72·5	2,127
(*b*) 0·0126 g. D.D.T. dust fortnightly	3·25	8·25	15·5	61·5	1,697
(*c*) 0·0252 g. D.D.T. dust weekly	0·5	0·75	4·75	53·0	1,664
(*d*) 0·0252 g. D.D.T. dust fortnightly	3·0	5·0	10·5	59·5	1,615
(*e*) 0·0252 g. D.D.T. liq. weekly	0·5	1·25	2·0	67·0	1,741
(*f*) 0·0252 g. D.D.T. liq. fortnightly	1·25	5·0	3·5	62·0	1,810
(*g*) 0·0063 g. D.D.T. liq. weekly	0·25	1·75	3·25	68·0	1,537
(*h*) 0·0063 g. D.D.T. liq. fortnightly	0·75	5·0	9·75	70·0	1,779
(*i*) Dieldrin blanket spray	0·75	1·5	0·5	33·75	1,698
(*j*) Control	3·0	19·25	34·5	88·0	1,434
Significance (P)	N.S.	<0·001	<0·001	<0·001	N.S.

TABLE 2.—SIGNIFICANT DIFFERENCES—BORED TILLERS

	All Treatments *v.* Control	Dieldrin *v.* D.D.T.	Weekly *v.* Fortnightly	Misc. Liq. *v.* Dusts	Rates in Dusts	Rates in Misc. Liq.	Interactions (All)
Sample 3	P<0·0001	P<0·0001	N.S.	NS	N.S.	N.S.	N.S.
Sample 4	P<0·001	P<0·001	P<0·001	P<0·001	N.S.	P<0·01	N.S.
Sample 5	P<0·001	P<0·001	N.S.	N.S.	N.S.	N.S.	N.S.

The third sample immediately before the final application of D.D.T. again showed no shoot fly control—the significant differences between and within treatments in the bored tiller counts are shown in Tables 1 and 2. The fourth sample taken at the flowering stage after all the D.D.T. treatments had ceased still showed no control of shoot fly.

No further applications of D.D.T. were given but the dieldrin blanket spray was continued up until harvest and during this time a heavy stalk borer population built up—*see* Table 1. Analysis of the fifth sample showed that there were no residual differences between the D.D.T. treatments.

The final figures obtained from this trial were the yields. In spite of large differences between treatments the figures were not significantly different from one another—mainly due to a high coefficient of variability (25 per cent). This analysis was carried out on the figures from the single row, the entire subplot and the entire plot and although slight differences occurred in no case did the order of the treatments change. (The yield figures quoted in Table 1 are those derived from the single row.) The yields did not correlate with the numbers of bored stems or with the amount of D.D.T. applied.

Analysis of the effect of removing the centre row at various stages of the crop's growth showed that there was no significant difference between the thinning treatments and that all treatments yielded less than the unthinned subplot ($P<0.01$).

THE 1958 EXPERIMENT

From the two previous experiments and other observations in other years it was obvious that there was no point in carrying out trials in the first rains. Also with the high coefficient of variability of the 1956 trials more replication would be needed. By far the cheapest and amongst the highest yielding treatments were the D.D.T. dusts and it was decided to continue with these only. Eight replicates of four treatments were laid down in the same way as the earlier experiments, the sampling method was to remain the same though less counts were to be taken. The treatments were as follows:—

- Five weekly applications of 1 per cent D.D.T. dust, five weekly and three fortnightly applications of 2 per cent D.D.T. dust and a control. The dust was applied down the open funnel with an imported shaker duster.

TABLE 3

TREATMENT	MEAN NO. OF BORED TILLERS		Yield lb./acre
	Sample 2	Sample 3	
5×1% D.D.T. dust	0	40·1	1,088
5×2% D.D.T. dust	0	41·0	815
3×2% D.D.T. dust	1·4	52·3	1,013
Control	7·4	61·6	975
Significance P ..	—	<0·001	N.S.
L.S.D. at 5% ..	—	8·3	—

The first sample showed that there were no stalk borers present before the treatments started. The second sample taken during the treatment period showed that borer was building up and was being controlled but that the general level of attack was very low with many nil counts. The third sample, at harvest, showed that both the weekly treatments had less bored tillers than the fortnightly and that all three had less than the control. Once again the yields were not significantly different from one another though it appears that the five applications of the 2 per cent dust had a depressing effect on the yield. There were no visible signs of phytotoxicity in the field and it hardly seems credible that a 2 per cent dust would have harmful effect on sorghum as strengths up to 10 per cent have been advocated in other countries on maize (Jepson, 1954).

DISCUSSION

The commonest species of borer in all these trials was the Pyralid (*Chilo zonellus*) and, although one can obtain varying degrees of control of this pest, it is very difficult to control it completely. On the other hand where the crop is being grown properly with adequate rainfall it is not possible to show significant increases in yield even with a large reduction in the numbers of borers present.

Probably the main reason for the apparent lack of response to borer control is that the sorghum tillers very heavily with an early borer attack and one can actually harvest more heads in a badly attacked plot. In the second rains trial in 1956 there more heads in the control plots than in the treated, they weighed less individually and their stems were shorter, all at the $P<0.01$ level. The final blow to insecticidal control is the cost: in the 1958 trial using 80 lb. of D.D.T. dust per acre the cost was over Sh. 100 per acre, without including labour.

SUMMARY

A report is given on three experiments to try and control stalk borers in sorghum in Uganda. Treatments consisted of varying numbers of applications and rates of D.D.T. dust and miscible liquid and a blanket treatment of dieldrin throughout the crop's growth. A trial in the first rains was a complete failure as no stalk borers attacked the crop. Two second rains trials gave varying degrees of control of stalk borer but no significant increases in yield were observed. This can be shown to be due to an increase in the number of tillers in the untreated plots, a corresponding increase in the number of heads, which, though weighing less, even out the yield. There are also slight indications that the stronger formulations are phytotoxic to the local sorghums.

ACKNOWLEDGMENTS

I am very much indebted to Mr. A. P. G. Michelmore and Mr. J. Bowden for encouragement and advice on the trials, to Mr. W. R. Mills for advice on the design and the analysis of the results and to my junior staff for carrying out all the field work and sampling. This paper is published by permission of the Director of Agriculture, Uganda.

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REVIEW

MINOR ELEMENTS AND THEIR EFFECTS ON THE GROWTH AND CHEMICAL COMPOSITION OF HERBAGE PLANTS by R. Dorrington Williams, published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks., England, 1959, pp. 68, price 7*s.* 6*d.*

This mimeographed publication deals with many aspects of minor element nutrition and although it refers primarily to plants it also deals with certain aspects of animal nutrition. The author stresses the necessity of correct diagnosis of deficiency before treatment of soil or plant and points out that it is possible to do more harm than good by applying minor elements indiscriminately. He once more draws attention to the disservice to agriculture implicit in the idea that minor elements will produce wonderful yields with no further trouble and expense.

As is usual with the publications of the Commonwealth Agricultural Bureaux, this book can be recommended to all who are interested in agriculture. The specialist in particular will find much to attract his attention, including the appendix table of the minor-element contents of many herbage species. At its price, it should be in the hands of every agricultural officer who conducts field experiments.

J.G.

WATER-SOLUBLE PHOSPHORUS IN SOME LOCAL FEEDS AND FAECES

By **H. W. Dougall, Grassland Research Station, Department of Agriculture, Kitale, Kenya**

(Received for publication on 24th July, 1959)

It is stated by Miller [1] that a considerable amount of the phosphorus contained in plant material is soluble in water and that for lucerne, for example, Ames and Boltz (loc. cit.) showed that 75 per cent of its total phosphorus is water-soluble.

The experiments described in this paper were undertaken with the object of determining under what conditions the water-soluble phosphorus contained in the dry matter of plant material could be measured, how it is distributed and how it may be affected by the stage of growth or age of the plant. A further object was to ascertain the solubility in water of the phosphorus contained in the dry matter of ruminant faeces as well as in the feeds from which such faeces were derived.

EXPERIMENTAL

One gramme samples of star grass previously ground in a laboratory mill to pass through a sieve containing apertures of 1 mm. diameter, were weighed into 100 ml. beakers: 50 ml. distilled water were added and the samples incubated at 38-40° C. for 1, 2, 4, 8, 12 and 24 h. periods respectively. After these periods, the grass was filtered, washed and its phosphorus determined by conventional procedure. The total phosphorus content of the grass was also determined and its water-soluble content was obtained by difference.

RESULTS

The results of this first experiment are shown graphically in Fig. 1. It is seen that after 8 h. incubation, the amount of water-soluble phosphorus contained in the dry matter of the grass decreases and that this decrease is particularly marked after the 24 h. incubation period. It was observed that a greyish-white film had developed on the surface of the grass resting on top of the water after the 12 h. incubation period and that a similar but appreciably denser film had developed after the 24 h. incubation period. These films may have resulted from bacterial activity and, working under this assumption, further samples of the same grass were incubated for the same periods, but this time in the presence of 5 ml. toluene. The results of this treatment are also shown in Fig. 1. It is seen that there is now a slight though progressive increase in the amount of water-soluble phosphorus extracted with time (t) up to a 24 h. extraction period. The equation expressing the relationship is:

$$\text{Water-soluble P in Star grass} = 0.0327 \times \log t + 0.386 \ (1 - r^2 = 0.075).$$

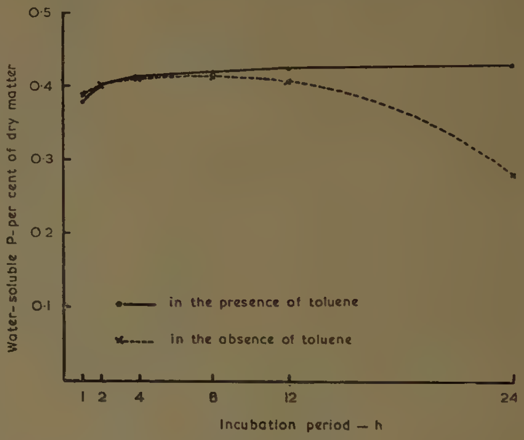

Fig. 1.—The solubility in water of the P contained in the Star grass.

Since there is little gain in extraction between 12 and 24 h. any suitable period of incubation within this range could be chosen without causing serious discrepancies: the 24 h. period was adopted as most convenient for future work.

DISTRIBUTION OF PHOSPHORUS IN PLANT MATERIAL

Using lucerne which had reached the flowering stage of growth and star grass which was still growing and without flowering heads, a study was made of the distribution of their total and water-soluble phosphorus. The lucerne was separated by hand into leaves, stems, side branches and flowers and the star grass into leaves and stems. The separated materials were oven dried for 24 h. at 100° C. in order to obtain their dry matter content. They were then ground in the laboratory mill and 1 gm. samples were incubated, this time at 30-31° C. for 24 h. in the presence of 50 ml. water and 5 ml. toluene. After filtering and washing, the phosphorus remaining in the materials was determined. Total phosphorus was also determined on 1gm. samples and the water-soluble phosphorus obtained by difference. The results of these determinations, expressed on a dry matter basis, are given in Table I.

TABLE I.—DISTRIBUTION OF TOTAL AND WATER-SOLUBLE PHOSPHORUS IN LUCERNE AND STAR GRASS
(*per cent of dry matter*)

	LUCERNE			STAR GRASS		
	Total P	Water-soluble P	Water-soluble / Total P	Total P	Water-soluble P	Water-soluble / Total P
Flowers ..	0·331	0·296	0·894	—	—	—
Leaves ..	0·231	0·200	0·866	0·293	0·271	0·925
Stems ..	0·094	0·078	0·830	0·283	0·256	0·906
Side Shoots	0·231	0·207	0·896	—	—	—
Whole plant	—	—	—	0·288	0·264	0·917

The lucerne flowers are the richest source of total and of water-soluble phosphorus and the stems are the poorest. The leaves and side branches contain identical amounts of total phosphorus and almost identical amounts of water-soluble phosphorus. In the actively-growing star grass the leaves and stems contain very similar amounts of total phosphorus, but the stems contain slightly less water-soluble phosphorus. The ratios of water-soluble to total phosphorus for the different parts of lucerne suggest that the proportion of water-soluble phosphorus may be higher than the value of 75 per cent quoted by Miller [1]. It is, however, almost certain that Ames and Boltz (loc. cit.) were using fresh, unground material, for when the fresh and unground leaves of lucerne are examined, their water-soluble phosphorus constitutes 75 per cent of the total. In the fresh, unground leaves and stems of star grass, the corresponding values are 85.2 and 74.5 per cent respectively. The fact that plant material is not ground does not entirely eliminate the possibility of escape of water-soluble phosphorus through the exposed tissues in the excised areas, as for example, the petiole of the leaves. To examine this point, the flowering heads of lucerne and stems of star grass each holding three leaves were treated in three different ways, viz. (i) the excised ends of the stems were sealed with paraffin wax; (ii) the excised ends were left exposed; and (iii) the plants were chopped into half-inch pieces, and their water-soluble phosphorus determined. On a dry matter basis, the chopped material gave up markedly more water-soluble phosphorus than either of the other treatments. For lucerne, sealing the excised part with paraffin wax caused a retention of water-soluble phosphorus but for the star grass, it appeared to make little difference.

EFFECT OF STAGE OF GROWTH ON WATER-SOLUBLE PHOSPHORUS

It is well known that the amount of total phosphorus contained in plant material is largely determined by the age of the plant and in order to find out if this is the case with water-soluble phosphorus also, estimations were made on oven-dried, milled samples of star grass that had been collected at one-week intervals over a period of eight weeks. The results of this experiment are shown graphically in Fig. 2, from which it is seen that the total phosphorus and the water-soluble phosphorus contained in the dry matter of this grass are each directly related to the stage of growth of the grass. The following equations express these relationships:

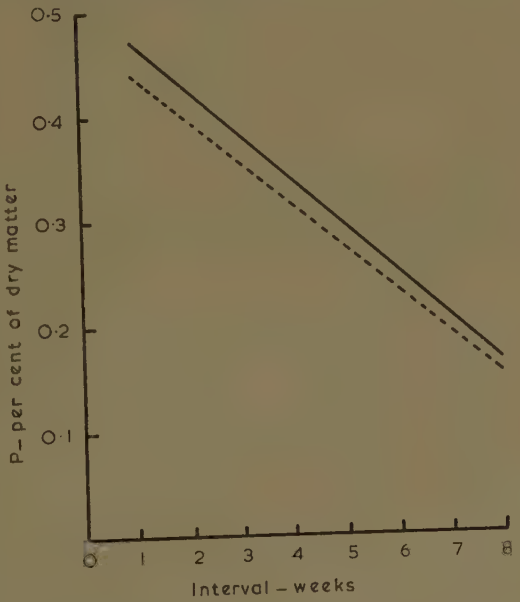

Fig. 2.—The total P (———) in relation to the water-soluble P (- - - - -) of Star grass at different stages of maturity.

Total P in star grass $= 0.515 - 0.044 \times t$ $(1 - r^2 = 0.032)$

Water-soluble P in star grass $= 0.480 - 0.041 \times t$ $(1 - r^2 = 0.038)$

where t = time in weeks from the first sample. There is no significant difference between the slopes of these regressions and the residual, unextracted phosphorus is given by the difference between the two constants and is 0.035 per cent. Throughout the sampling period, the ratio water-soluble/total phosphorus was 0.928 ± 0.013.

WATER-SOLUBLE PHOSPHORUS IN RUMINANT FAECES

It was noted earlier that the bacteria associated with the unprotected extraction of star grass depress its content of water-soluble phosphorus. This same result holds for the bacteria associated with faeces of ruminant origin, and again as in the case of star grass, toluene gives protection against loss to bacteria. The total phosphorus and the water-soluble phosphorus contained in the dry matter of the faeces of three ruminants are given in Table II.

TABLE II.—TOTAL P AND WATER-SOLUBLE P IN RUMINANT FAECES

(*per cent of dry matter*)

Animal	Total P	Water-soluble P	Water-soluble / Total P
1.. ..	0·820	0·555	0·677
2.. ..	1·056	0·670	0·634
3.. ..	0·804	0·481	0·598

It is apparent that the ratios of water-soluble to total phosphorus are less than those recorded earlier for a grass and a legume.

To verify this result the total phosphorus and the water-soluble phosphorus contained in the dry matter of the three separate feeds which composed the ration of six Jersey cows in milk were examined, together with the faeces voided by these animals. The results of the feed determinations are given in Table III.

TABLE III.—THE PHOSPHORUS COMPOSITION OF THE SEPARATE FEEDS

(*per cent of dry matter*)

Feed	Total P	Water-soluble P	Water-soluble / Total P
Maize meal	0·227	0·165	0·73
Cotton seed cake	0·992	0·742	0·75
Grass ..	0·215	0·170	0·79

The six cows received 10 lb. of a mixture consisting of two parts of cottonseed cake and one part of maize meal. Their dry matter intake was satisfied by grass of known amount and dry matter content. The percentage content of total and of water-soluble phosphorus of the ration as a whole could therefore be computed and it is shown in Table IV.

TABLE IV.—THE PHOSPHORUS COMPOSITION OF THE FEED AS A WHOLE

(*per cent of dry matter*)

Animal	Total P	Water-soluble P	Water-soluble / Total P
1.. ..	0·399	0·308	0·772
2.. ..	0·420	0·319	0·760
3.. ..	0·494	0·379	0·767
4.. ..	0·430	0·329	0·765
5.. ..	0·432	0·333	0·771
6.. ..	0·431	0·329	0·763
Mean ..	0·434	0·333	0·766
S.E. of the mean ..	0·013	0·010	0·002

The phosphorus composition of the faeces of the same six animals is shown in Table V.

TABLE V.—THE PHOSPHORUS COMPOSITION OF THE FAECES (*per cent of dry matter*)

Animal	Total P	Water-soluble P	Water-soluble / Total P
1.. ..	1·095	0·655	0·598
2.. ..	0·636	0·281	0·442
3.. ..	0·748	0·478	0·639
4.. ..	0·844	0·416	0·492
5.. ..	0·776	0·387	0·498
6.. ..	0·984	0·566	0·575
Mean ..	0·847	0·464	0·541
S.E. of the mean ..	0·068	0·054	0·031

Both the mean total phosphorus and the mean water-soluble phosphorus contained in the dry matter of the faeces are higher than the corresponding values for the feed and differ from them at the 0.1 and the 5 per cent level of significance respectively. When the ratio water-soluble/total phosphorus is examined, however, it is apparent that the ratio 0.766 ± 0.002 for the feed is higher than the corresponding ratio 0.541 ± 0.031 for the faeces and differs from it at the 0.1 significance level. This result implies that there is a loss of water-soluble phosphorus to the animal as is only to be expected as part of the normal digestive process. Calculations from the data given in

Tables IV and V show also that water-soluble phosphorus is directly related to total phosphorus in both feed and faeces and the following equations express these relationships:

Water-soluble P in feed = 0.00087 + 0.764 × Total P in feed ($1 - r^2 = 0.007$)

Water-soluble P in faeces = −0.16818 + 0.746 × Total P in faeces ($1 - r^2 = 0.125$).

There is no significant difference between the slopes of these regressions which are shown graphically in Fig 3. According to the latter equation, no water-soluble phosphorus would be found in the faeces if the total phosphorus contained in the faeces reached the level of 0.225 per cent of the dry matter. It is interesting to note that another Jersey cow feeding from pasture that contained 0.238 per cent of total phosphorus and 0.203 per cent of water-soluble phosphorus in its dry matter, voided faeces that contained 0.482 per cent of total phosphorus, including 0.184 per cent of water-soluble phosphorus. These actual values for the water-soluble phosphorus estimated in feed and faeces are in close agreement with those obtained by interpolation from the appropriate regression at the quoted levels of total phosphorus.

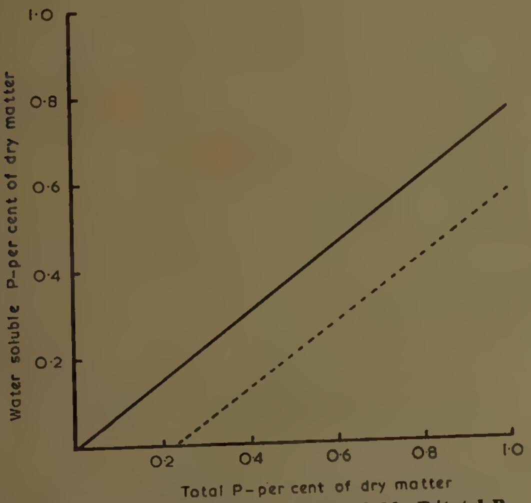

Fig. 3.—The relationship—water-soluble P/total P in feeds (———) and in faeces (- - - - - -) derived from the feeds.

PHOSPHORUS ASSOCIATED WITH $N-H_2SO_4$ FIBRE

It is known that when feeds and faeces are first freed from fats by boiling alcohol/benzene mixture and then digested for 1½ h. with 1.5 N − H_2SO_4, the fibre resisting digestion has nitrogen in association [2]. Exploratory work showed that "feed" and "faeces" fibres obtained in this way have also phosphorus in association. When the feeds and faeces of the six Jersey cows were examined, it was found that the mean phosphorus associated with N − H_2SO_4 fibre amounts to only 0.0116 ± 0.0006 per cent and 0.04 ± 0.002 per cent of the dry matter respectively, but that the difference between these two means is significant at more than 1,000/1. Similarly the phosphorus not associated with the fibre of the feed is significantly lower than that of the faeces but the ratio, P not associated with N − H_2SO_4 fibre/total P, 0.973 ± 0.0005 for the feed is higher than the corresponding ratio 0.951 ± 0.005, for the faeces and differs from it at more than 100/1. When the regression of the P not associated with N − H_2SO_4 fibre on total P is examined for both feed and faeces, however, the regression coefficients are not significantly different and the respective equations are:

P not associated with N − H_2SO_4 fibre of feed = 0.958 × Total P in feed + 0.007 ($1 - r^2 = 0.0002$)

P not associated with N − H_2SO_4 fibre of faeces = Total P in faeces − 0.040 ($1 - r^2 = 0.001$).

Since the total phosphorus in the dry matter of feeds and faeces is directly related to the water-soluble phosphorus, it should follow that the P not associated with the fibre of feeds or faeces is also related to water-soluble phosphorus and this is so. The respective equations are:

P not associated with fibre of feed = 1.245 × Water-soluble P in feed + 0.008 ($1 - r^2 = 0.008$)

P not associated with fibre of faeces = 1.186 × Water-soluble P in faeces + 0.257 ($1 - r^2 = 0.107$).

These regression coefficients are not significantly different.

The phosphorus associated with the acid fibre of the feeds accounts for 11.5 per cent of the non-water-soluble phosphorus of the feed on a dry matter basis and for 10.7 per cent of the corresponding fraction of the faeces, which would indicate that such "bound" phosphorus may be passing through untouched by the process of digestion.

CONCLUSION

It is apparent that the amount of water-soluble phosphorus found in plants is influenced by the state of sub-division of the plant and by the stage of growth of the plant which in turn influences the distribution of phosphorus. Throughout the growth of star grass, the ratio water-soluble/total phosphorus is constant and 92.8 per cent of the total phosphorus contained in its dry matter is in water-soluble form. In the feed given to Jersey cows, 76.6 per cent of the total phosphorus contained in the dry matter is water-soluble.

The water-soluble phosphorus contained in the dry matter of the faeces examined is significantly higher than in the feed, but the ratio water-soluble/total phosphorus is significantly higher in the feed than in the faeces and there is no significant difference between regression coefficients when the regressions of water-soluble on total phosphorus are calculated for feed and faeces.

Phosphorus occurs in association with $N - H_2SO_4$ fibre of feeds and faeces, constituting 11.5 per cent of the non-water-soluble fraction of the dry matter of the former and 10.7 per cent of the latter. The phosphorus not associated with the fibre of both feeds and faeces is directly related to the total and to the water-soluble phosphorus contained in each.

From a practical standpoint such as that of green manuring, the high proportion of water-soluble phosphorus contained in plants should be an advantage, but from the standpoint of fodder conservation such as by hay-making, losses of water-soluble phosphorus will be incurred and these may be severe if the weather turns unfavourably.

Just over 50 per cent of the total phosphorus contained in the faeces examined is water-soluble, and where similar ruminant faeces are used to increase crop production, full advantage of their water-soluble content should be taken by applying the dung to each crop in turn.

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DOSAGE DISTRIBUTION UPON HAND-SPRAYED COTTON

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(*Received for publication on 22nd July, 1959*)

Cotton is grown extensively as a cash crop by peasant farmers in East Africa, and is often subject to severe attack by insect pests such as Jassids (*Empoasca* spp.), Bollworm (*Heliothis armigera*) and Spiny Bollworm (*Earias* spp.). The cotton is mostly planted in small plots, and it seems likely that applications of insecticides in the near future will be made with small portable machines rather than with larger power-driven equipment.

McKinlay (1956, 1957), for example, used a Four Oaks "Ross" Knapsack Sprayer in his experimental work, and has recorded very substantial increases in yield, with well grown cotton. In some experiments he varied his methods of application and volume dosages, and obtained varying degrees of control, in most cases probably as a result of variations in the distribution of dosages of insecticides upon the plants.

It was therefore considered worthwhile investigating how the methods of application affected the distribution of insecticides upon the cotton plants, even though it is rarely possible to obtain more than qualitative correlation between such measurements and the degree of pest control. The tests were made upon exceptionally well-grown cotton in the Eastern Province of Tanganyika. The plants were three months old at the time of treatment, and some of them were about 5 ft. tall; within the rows they were 6 in. apart, and the rows were 1 yd. apart. The growth was so great that the plants from adjacent rows met near the ground, so that the conditions of the experiment were somewhat exceptional.

METHODS OF APPLICATION

Four methods of application were investigated. Unavoidably, there were variations in the techniques of application as well as in the volume dosages per acre, and the treatments were as follows:—

(1) Using a single Allman 00 nozzle, giving an average emission rate of 0.14 gallons per minute at a pressure of just over 40 p.s.i., an attempt was made to spray all parts of the plant until liquid dripped from the leaves. Attempts were made to apply insecticide to the under surfaces of the leaves as well as upper surfaces, and for this reason a right-angled adaptor was fitted to the end of the spray lance. The volume dosage was 363 gallons per acre.

(2) An Allman 1 nozzle was used, with an emission rate of 0.26 gallons per minute at a pressure of 30 p.s.i. A right-angled adaptor was again used; spraying sideways, the fan of spray was so arranged that it was vertical, and at right-angles to the rows, when the nozzle was held mid-way between the tops of the plants. The nozzle was swept in an arc from the tops to the bottoms of the plants as the operator walked down the rows, and both sides of a row were treated in this fashion. About 180 gallons were applied per acre, considerably more than was intended.

(3) This application was made with two Allman 000 nozzles, which were fitted 10 in. apart on a lance and pointed outwards at about 25° to the line of walk. The lance was held about 1½ ft. above the cotton plants, with the fan of spray roughly horizontal. Spray was applied by walking down alternate rows. The nozzles operated at an average pressure of about 30 p.s.i., giving a combined emission rate of about 0.15 gallons per minute, and the volume dosage was 14 gallons per acre.

(4) Here the method of application was basically the same as for Treatment (3), except that only one Allman 000 nozzle was used; operating at about 55 p.s.i., an emission rate of 0.10 gallons per minute was obtained, and eight gallons were applied per acre.

Relevant field data for the four treatments are given in Table 1; the parameters of the droplet distributions were interpolated from unpublished measurements of droplet sizes produced under slightly different operating conditions.

THE MEASUREMENT AND SAMPLING OF DOSAGES

A water-soluble dye (Croceine Scarlet) was included in emulsions similar to those used by McKinlay (1956, 1957), and deposits were estimated colorimetrically. From these determinations, equivalent deposits of insecticide were calculated by assuming that in all treatments 1 lb. of insecticide was applied per acre.

TABLE 1.—RELEVANT DATA FOR THE FOUR APPLICATIONS

Date	Treatment	Volume dosage gall./acre	METEOROLOGICAL READINGS AT 6 FT.			Wind direction °M	Volume median diameter (microns)
			Air temp. °F.	Windspeed f.p.s.	Relative humidity per cent		
20·5	1	363	70·2	2·5	89	075	240
31·5	2	180	72·6	2·7	79	280–310	330
28·5	3	14	75·7	4·1	70	065	230
25·5	4	8	72·8	1·8	78	055	210

The rows of cotton were along a direction of 135°–315° M.

The samples were in three main groups—

(*a*) from the tops of the plants;

(*b*) from the lower portions of the outer parts of the plants, at sites approximately mid-way between the rows; and

(*c*) from lower portions within the plants and along the planting lines.

Numbers of leaves, bolls or squares, were picked from the three sites. Only total dosages were determined for the bolls and squares because it was difficult to assign any accurate geometrical description to them; since the squares, and more particularly the bolls, were more developed near the bottom of the plants than at the top, this almost certainly gave comparatively higher figures for groups (*b*) and (*c*) than for group (*a*). For the leaf samples, areas were estimated by tracing out leaf shapes upon paper, cutting out the silhouettes and weighing them. In the main analysis, deposits were calculated in terms of Total dosage ÷ Area of one side of the leaf, but for the two high-volume applications, deposits upon upper and lower surfaces were also examined separately.

The work was exploratory, and as many samples as possible were collected and estimated. This resulted in unequal numbers of samples for the different trials, and made it difficult to carry out an elegant analysis of variance upon the data. It is felt, however, that the "extra" samples added enough to the knowledge of dosage variations to warrant their inclusion.

The data must be normalized before most information can be extracted from them. In many cases this is not easy and, furthermore, it can happen, for very sound reasons, that two groups of samples have different variances even after satisfactory normalization. In general, therefore, one can expect to have data in which not only the means of groups of samples, but also their variances, show significant differences, and it also seems likely that the normalization of data would not be possible by a universally applicable transformation, but only by ones pertinent to specific cases.

The statistical analysis of dosage distribution is therefore likely to be a complex affair involving procedures not normally used by non-specialists in statistics. A preliminary examination of the data showed that the dosage distribution was positively skew, often very much so. This suggested that a logarithmic transformation would give normal distributions, but, to include samples with no deposit upon them it was necessary to use as variable $x = \log (D + a)$ where D was the dosage, and a some constant.

The choice of a seemed to be a matter of trial and error. Initially, Fisher's k— statistics (*see* for example, Snedecor, 1956) were used to test for normality, but this was very laborious and, finally, a graphical method was adopted. For a group the percentage of samples with dosages up to a certain value was calculated, and this was plotted against (D + a) on *log-probit* paper, using various values of a. The value chosen for a was the smallest to give linear graphs.

RESULTS

A detailed account of the complex statistical analyses will not be given, particularly because it is often unreal to discuss mean dosages when it is the distributions of dosages that are most important. For completeness, however, all the main parameters will be presented.

Representative distributions are given in Fig. 1, where good linear plots are obtained for the dosages on squares and bolls if $x = \log (D + 0.02) (10^2)$ where D is the dosage in mgm.; while for leaves $x = \log (D + 4)$ where D is in mgm./m^2.

TABLE 2.—STATISTICAL PARAMETERS FOR THE DOSAGE DISTRIBUTIONS

Treatment	Site	SQUARES AND BOLLS				LEAVES			
		Mean of $\log_{10}(D+0{\cdot}02)$ (10^2)	σ^2	No. of samples	D*	Mean of $\log_{10}(D+4)$	σ^2	No. of samples	D*
1	A	0·68	0·010	14	0·027	1·069	0·013	21	7·7
	B	0·68	0·011	28	0·028	1·013	0·007	21	6·3
	C	0·71	0·028	27	0·031	0·955	0·013	21	5·0
2	A	0·89	0·022	14	0·058	1·328	0·005	14	17·3
	B	0·81	0·025	14	0·045	1·346	0·022	14	18·2
	C	0·67	0·026	14	0·027	1·244	0·020	14	13·6
3	A	0·76	0·037	24	0·038	1·800	0·082	24	59·1
	B	0·56	0·046	24	0·017	1·105	0·070	24	8·7
	C	0·56	0·042	24	0·016	0·976	0·044	24	5·5
4	A	0·76	0·097	24	0·037	1·701	0·292	18	46·2
	B	0·47	0·034	24	0·010	1·152	0·134	18	8·2
	C	0·42	0·014	24	0·006	0·796	0·028	18	2·3

*D is the value obtained from the mean of $\log_{10}(D+a)$

TABLE 3.—BARTLETT'S TESTS FOR HOMOGENEITY OF VARIANCES

Treatment	SQUARES AND BOLLS			LEAVES		
	B/C	d.f.	Significance	B/C	d.f.	Significance
1	7·3	2	$0{\cdot}05 > P > 0{\cdot}02$	2·3	2	$0{\cdot}5 > P > 0{\cdot}1$
2	0·1	2	$0{\cdot}9 > P > 0{\cdot}5$	7·0	2	$0{\cdot}05 > P > 0{\cdot}02$
3	0·3	2	$0{\cdot}9 > P > 0{\cdot}5$	4·4	2	$0{\cdot}5 > P > 0{\cdot}1$
4	17·7	2	$P << 0{\cdot}001$	16·0	2	$P < 0{\cdot}001$
All	45·5	11	$P << 0{\cdot}001$	135	11	$P << 0{\cdot}001$

TABLE 4.—DOSAGES UPON UPPER AND LOWER LEAF SURFACES

Treatment	Site	No. of samples	Mean of $\log_{10} \frac{(D_T + 4)}{(D_B + 4)}$	σ	$\frac{(D_T + 4)}{(D_B + 4)}$*
1	A	21	0·0954	0·120	1·25
	B	21	0·1290	0·087	1·35
	C	21	0·1977	0·142	1·58
2	A	14	0·1225	0·194	1·33
	B	14	0·5020	0·130	3·18
	C	14	0·5020	0·146	3·82

*This is calculated from the mean of $\log_{10} \frac{(D_T + 4)}{(D_B + 4)}$

The main statistical parameters for each group of samples are listed in Table 2. Applying Bartlett's test for homogeneity, as described by Brownlee (1949), it was found that while the variances were homogeneous for each of Treatments 1, 2 and 3, or nearly so, this was not the case for Treatment 4, and a test on all groups together showed wide divergence from homogeneity; these statistical tests are summarized in Table 3. Within treatments, reasonably valid conclusions can therefore be drawn from the standard statistical procedures, but conclusions upon differences between treatments are less reliable.

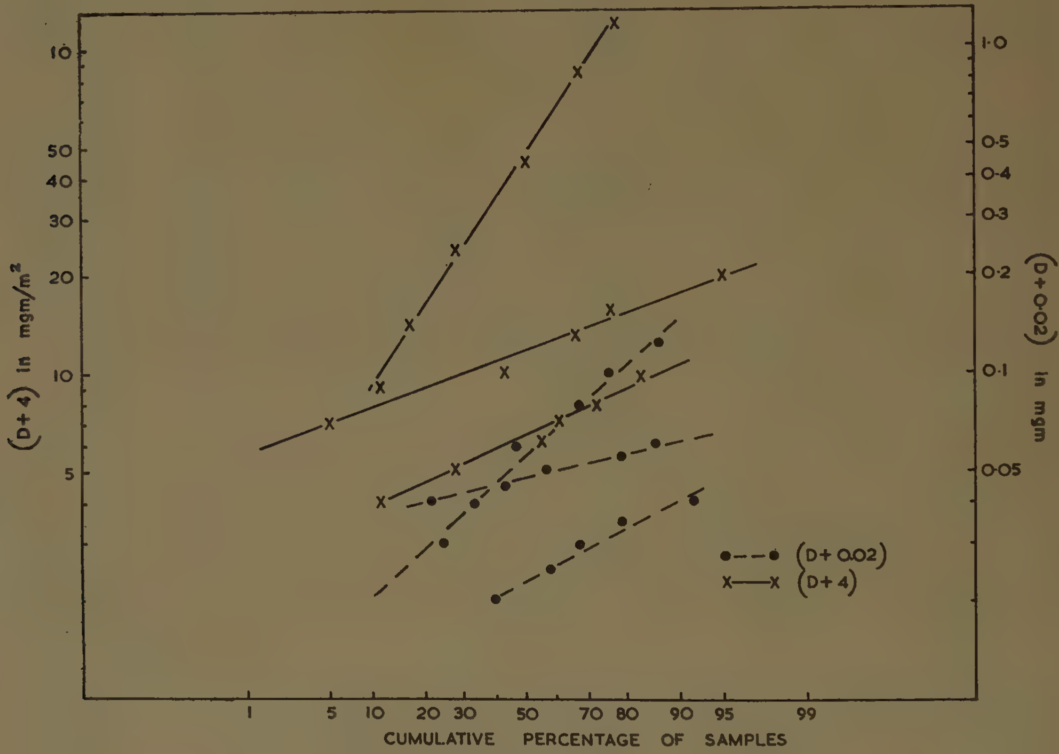

Fig. 1.—Typical dosage distributions, plotted on *log-probit* paper.

It was only in Treatments 1 and 2 that appreciable deposits were detected upon the lower leaf surfaces. Analysing the data in terms of

$$x = \log \left\{ \frac{D_T + 4}{D_B + 4} \right\}$$

where D_T and D_B were the dosages on the upper and lower surfaces respectively, it was shown by t-tests that there were significant differences between the dosages on the two surfaces, the upper surface receiving the larger deposit. The data are summarized in Table 4.

Discussion

From what might be termed the "operational" point of view, a good application would be one in which dosage variations were as small as possible, and this would be expected to give the best results, for a given outlay of insecticide, for a relatively immobile pest. A scale insect might be cited as a typical pest falling into this category, and adequate applications of fungicides would generally aim to meet this criterion of uniform cover. For mobile pests the criterion of uniformity of cover need not be so stringent, and it is, indeed, possible that a treatment with wide variations of dosage, giving sites of high dosage interspersed with sites of negligible dosage, might sometimes give better control than one of more uniform distribution. With some pests it is important to treat both surfaces of the leaf, whereas with others it is not. Evidently, therefore, an "adequate" application is likely to be governed greatly by the behaviour of the pest that is being attacked, and particularly by its movements, and a close correlation between dosage distributions and the degree of control would only be possible if there were very detailed ecological information.

In Treatment 1, the dosages in the three sites show some differences, but there is a reasonably uniform cover of most parts of the plant. The under-surfaces receive an appreciable dosage, but at a significantly lower level than the upper surfaces, particularly in the central parts of the bottoms of the plants. Treatment 2 shows a similar pattern of dosage distribution except that the overall dosages on squares, bolls and leaves show an increase over those achieved in Treatment 1, and there is a very pronounced drop in dosage levels on the under-surfaces in sites B and C, both near the bottom of the plant; the variations in dosage are generally higher. Treatments 3 and 4, at low volume dosages, are very strikingly different, however, from the treatments at high volume dosages. Near the top of the plant, the dosages on squares and bolls are high. At the bottom of the plants, however, the dosages are appreciably low, particularly in Treatment 4; the variations in dosage are also generally very high, with considerable proportions of the samples having little or no dosage. There were no detectable deposits on the under surfaces of the leaves in any of the sites.

In general, the results are not unexpected. When the nozzle is held above the crop during the entire spraying operation, as in Treatments 3 and 4, it is the uppermost exposed parts of the plant that receive the high dosages; attenuation of the spray by foliage, and shielding, reduces dosages in the lower levels and gives rise to areas with little or no dosage, and in no site is there deposition upon under-surfaces. If the nozzle is moved down into the crop as in Treatment 2, then dosages at the top of the plants are reduced, notably on the leaves, but there are increased dosages in the lower levels, and some spray, with a vertical component of velocity, is deposited upon under-surfaces. A conscious effort to spray to "run off", as in Treatment 1, and to treat under-surfaces, gives a somewhat more uniform cover, but the dosage levels are generally lower than in Treatment 2, except on the under-surfaces. The greater variations, for Sites A in Treatments 3 and 4, can probably be attributed to the fact that the spraying was done by moving down alternate rows, and that there was insufficient dispersal of the spray to prevent dosage variations across the swathes.

It is of interest to compare these assessments with work done by McKinlay (1956, 1957) in controlling bollworm, spiny bollworm and cotton stainers. There were slight differences in technique, but his treatments and results can be closely represented by Table 5, which shows that the best control was achieved with Treatment 1, but at greatly increased dosage of insecticide per acre; Treatment 2 also gave good control, but Treatments 3 and 4, at low volume, resulted in yields only about half those obtained with Treatment 1, but these yields were still many times those from unprotected plots.

Table 5.—Yield of Seed Cotton in lb. per Acre for the Various Applications (McKinlay, 1956, 1957)

Treatment	Dosage in lb./acre		Yield lb./acre
	DDT	γ BHC	
Series 1—			
1	3·0	0·75	2,024
2	1·0	0·25	1,616
4	1·0	0·25	1,222
Control	0	0	217
Series 2—			
3	1·0	0·25	1,380
4	1·0	0·25	1,284
Control	—	—	—

Using the data of Tables 2 and 5 it is possible to construct graphs showing the sort of dosage distributions achieved in McKinlay's work. These are presented in Figs. 2 and 3. In the "run-off" spray dosages on bolls and squares are consistently higher than in any other treatment, while his treatment at 100 gallons per acre, here identified with Treatment 2, gave intermediate dosages; with the low volume applications there were greatly reduced dosages in Sites B and C, and some 10-20 per cent of the bolls or squares in these sites received a negligible deposit. A somewhat similar picture emerges from the dosage distributions on leaves, except that in Site A the low volume applications give very high dosages on a proportion of the leaves, and the two high volume applications give comparable *total* dosages in all three sites, although in the "run-off" spray an appreciable proportion of the spray was, in fact, on the under-surfaces.

The data give an interesting illustration of the difficulties encountered when attempts are made to correlate the distributions of insecticides upon a crop with the resultant effect upon the insect pest and upon yield. Figures 2 and 3 show that the low volume applications resulted in extremely poor cover in the lower parts of the plants, and yet there was very

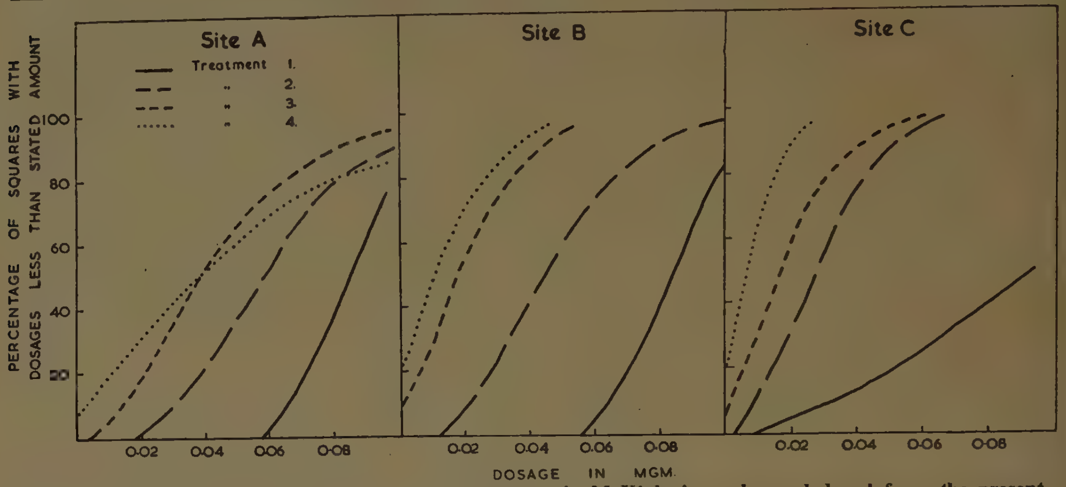

Fig. 2.—The dosage distributions on bolls and squares in McKinlay's work, as deduced from the present measurements.

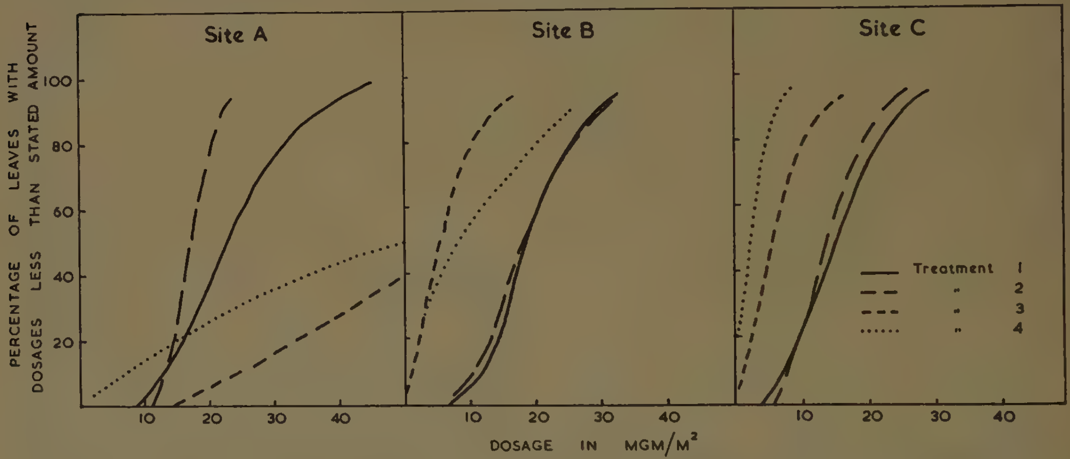

Fig. 3.—The dosage distributions on leaves in McKinlay's work, as deduced from the present measurements.

marked control of insect damage in McKinlay's work, and substantial increases in yield of cotton; it seems that the pests must have been sufficiently mobile to come into contact with the more highly dosed portions of the plant, thus eliminating to a considerable extent the possibility of poor control resulting from poor insecticide cover. Furthermore, control is usually necessary on cotton for a period of two months or so, during which the plants increase very considerably in size and in density of leaf cover; probably the dosage data given in this paper apply to the most extreme cases of attenuation and shielding likely to be met in the field.

SUMMARY

A description is given of the dosage distributions achieved by hand spraying cotton in four ways. It is shown that under-leaf cover is not achieved if the spray is released above the crop, and that in fully-grown cotton plants there is a considerable degree of attenuation of the spray before it reaches the lower and middle portions of the plants. High volume applications, particularly designed to spray all parts of the plant, gave a reasonably uniform cover throughout the plants, and appreciable deposits on the under surfaces A qualitative correlation exists between the dosage distributions and the degree of insect control.

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COLEOPTERA ASSOCIATED WITH STORED PRODUCTS IN UGANDA

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(*Received for publication on 25th June, 1959*)

As a result of a survey mainly in the Northern, Eastern and Western areas of the Protectorate and a study of the large number of available specimens in the Kawanda Research Station insect collection a list of the Coleoptera found associated with stored food products has been drawn up.

For convenience and to avoid undue repetition a code has been adopted as follows:—

1. Abundance is indicated by:—

VC. = Very Common, C. = Common, UC. = Uncommon, R. = Rare, VR. = Very Rare.

2. Distribution is indicated by:—

U. = Universal, WP. = Western Province, NP. = Northern Province, EP. = Eastern Province, Ank. = Ankole, Bu. = Bugisu, Bug. = Buganda, Bus. = Busoga, Bun. = Bunyoro, T. = Teso.

3. Commodities in which the insects named have been found are indicated by a code number as follows:—

1. Maize
2. Maize Meal
3. Maize Undried
4. Maize Bran
5. Wheat
6. Wheat Flour
7. Wheat Germ Meal
8. Wheat Bran
9. Wheat Shredded
10. Barley (Malt)
11. Sorghum
12. Rice
13. Rice (Paddy)
14. Cotton Seed
15. Cotton Seed Cake
16. Cotton Seed Meal
17. Groundnut (Decorticated)
18. Groundnut (Undecorticated)
19. Groundnut Cake
20. Groundnut Meal
21. Sunflower
22. Castor Seed
23. Shea Butternut
24. Walnut
25. Almond
26. Cashew-nut
27. Sim Sim
28. Sim Sim Cake
29. Sweet Potato (Dried)
30. Cassava (Dried)
31. Bean
32. Bean, Tepary
33. Bean, Soya
34. Pea
35. Pea, Cow
36. Pea, Pigeon
37. Gram, Green
38. Coffee (Unprocessed)
39. Coffee (Processed)
40. Tobacco
41. Citrus Fruit
42. Yeast (Dried)
43. Biscuits
44. Insect specimens (Dried)
45. Plant specimens (Dried)
46. Bone
47. Ham, Cured
48. Hides
49. Fish (Dried)
50. Fish (Salted)
51. Seed, Borassus
52. Seed, Albizzia
53. Seed, Hydrocarpus
54. Seed of Dolichos Lablab
55. Curry Powder
56. Ships and Barges on Lake Victoria
57. Larders
58. Books
59. Paper
60. Leather

Species marked with an asterisk are new records for Uganda.

Species	Distribution	Commodity
ANOBIIDAE—		
Catorama herbarium (L)	C. Bug.	14, 58, 59, 60.
Lasioderma serricorne (F)	VC. U.	1, 2, 5, 17, 23, 29, 35, 40, 42, 53, 55.
Stegobium paniceum (L)	UC. Bug.	5, 43 55.
ANTHICIDAE—		
Anthicus floralis (L)	UC. Bug., Bus., NP.	1, 14.
ANTHRIBIDAE—		
Araecerus fasiculatus (Deg)	VC. U.	1, 11, 12, 29, 30, 37.
BOSTRICHIDAE—		
Bostrychoplites cornutus (Oliv)	UC. Teso, WP.	29, 30.
Dinoderus minutus (F)	VC. U.	1, 11, 29, 30, 37.
Heterobostrychus brunneus (Murr)	UC. Teso.	29.
Rhizopertha dominica (F)	VC. U.	1, 11, 29, 30.
BRUCHIDAE—		
Acanthoscelides obtectus (Say)	VC. U.	31, 32, 34, 35.
Bruchidius atrolineatus (Pic)	C. NP., WP.	31, 35. 36.
Callosobruchus chinensis (L)	C. U.	22, 33, 35, 36, 37.
Callosobruchus maculatus (F)	C. U.	32, 33, 35, 36, 37.
Callosobruchus phaseoli (Gyll)	VR. Ank.	38 ,54.
**Spermophagus subfasciatus* (Boh)	VR. Bug.	56.
Callosobruchus analis (F) recorded in Kawanda collection and elsewhere is a misidentification of *C. maculatus* (F).		
CARABIDAE—		
**Egadroma* sp.	R. Bug.	1, 2.
CLERIDAE—		
Necrobia rufipes (Deg)	UC. Bug., EP.	46, 47, 50.
Thaneroclerus buqueti (Lef)	VR. Bug., Teso.	29, 40.
COLYDIIDAE—		
**Euxestoxenus rotundus* (Ar)	VR. 1 Record only Bug.	1.
CUCUJIDAE—		
Cryptolestes ferrugineus (Steph)	UC. Bug., Bus., Ank.	1, 11.
Cryptolestes minutus (01)	VC. U.	1, 2, 11, 12, 14, 30.
**Cryptolestes pusilloides* (Steel & Howe)	UC. Bug., Bus., Ank.	1.
**Cryptolestes turcicus* (Grouv)	VR. Bug.	Imported 7.
Cryptolestes ugandae (Steel & Howe)	C. NP., EP.	1, 2, 11, 12, 14.
**Planolestes cornutus* (Grouv)	C. Bug.	1, 52.
CURCULIONIDAE—		
Calandra oryzae (L)	VC. U.	1, 5, 11, 12, 23, 29, 30, 31, 32, 35
**Calandra granarium* (L)	VR. Bus.	10.
DERMESTIDAE—		
Attagenus gloriosae (F)	UC. Bug., Bus., T.	1, 18, 57.
Dermestes ater (Deg)	UC. Bug., Bus.	2, 56, 57.
Dermestes frischii (Kug)	VR. Bug.	56.
Dermestes maculatus (Deg)	UC., Bug., Bus., Bun.	47, 48, 49, 57.
ENDOMYCHIDAE—		
**Mycetea hirta* (Marsh)	R. Bug.	14.
LATHRIDIIDAE—		
**Enicmus minutus* (L)	VR. 1 Record only Bug.	1.
LYCTIDAE—		
Lyctus africanus (Lef)	R. Teso.	18, 30.
Lyctus brunneus (Steph)	C. U.	29, 30.
MONOTOMIDAE—		
**Monotoma spinicollis* (Aube)	VR. 1 Record Bug.	1.

SPECIES	Distribution	Commodity
MYCETOPHAGIDAE—		
**Litargus balteatus* (Lec)	VR. 1 Record Bug.	2.
Typhea stercorea (L)	C. Bug.	1, 14.
NITIDULIDAE—		
Brachypeplus parallelus (Murr)	C. Bug.	3.
Brachypeplus piloseticus (Murr)	C. Bug.	1, 3.
Carpophilus dimidiatus (F)	VC. U.	1, 17, 28, 30, 41, 42.
Carpophilus hemipterus (L)	VC. U.	3, 41, 51.
Carpophilus obsoletus (Erich)	C. EP.	17, 18, 30, 31, 36.
OSTOMIDAE—		
Lophocateres pusillus (Kug)	VC. U.	2, 13, 14, 21, 22, 29, 30, 31, 33, 36, 37.
Tenebroides mauritanicus (L)	VC. U.	1, 2, 4, 8, 9, 11, 14, 18, 21, 30, 31, 32, 37.
PTINIDAE—		
Gibbium psylloides (Czemp)	UC. Bug., Bu., Bun.	1, 5, 16.
SILVANIDAE—		
Ahasverus advena (Waltl)	VC. Bug., Bus.	1, 4, 38.
Oryzaephilus mercator (Fav)	VC. U.	1, 2, 12, 14, 17, 23, 24, 25, 26, 27, 28, 35, 42.
Oryzaephilus surinamensis (L)	VC. U.	1, 2, 11, 23.
**Silvanophloeus* sp.	VR. Bug.	1.
Silvanus quadricollis (Reitt)	R. Bug.	3.
TENEBRIONIDAE—		
Alphitobius diaperinus (Panz)	UC. Bug., Bus.	1, 2, 8, 14.
Alphitobius laevigatus (F)	VC. U.	1, 2, 11, 14, 21, 23, 30.
Gnathocerus cornutus (F)	UC. Bug., Ank.	2, 11, 30, 37, 45.
Gnathocerus maxillosus (F)	UC. Bug.	2.
Latheticus oryzae (Waterh)	C. NP., Bug., Bus.	1, 2, 11, 17, 37.
Palorus ratzeburgi (Wissm)	UC. Bug., Bus.	1, 2, 17.
Palorus subdepressus (Woll)	UC. Bug., Bus., Ank.	2, 11, 26.
Peristeptus marginalis (Geb)	VR. Bug.	8.
Platydema sp. (not in B.M.)	VR. Bug.	1.
Tenebrio nitidulus (Geb)	UC. Bug., Bu., Ank.	1, 18, 31.
Tribolium castaneum (Hbst)	VC. U.	1, 2, 4, 5, 6, 7, 11, 12, 14, 15, 17, 19, 23, 25, 29, 30, 31, 40, 44.
**Tribolium confusum* (J du V)	C. usually NP. R. in S. Ank., Bug. and Bus.	2, 7, 12, 27, 29, 30.
THORICTIDAE—		
Thorictodes heydeni (Reitt)	UC. Bug., Bus., EP.	1, 2.

ACKNOWLEDGMENTS

My thanks are due to Mr. L. Lefkovitch for the determinations of *Silvanophleous* and *Planolestes* and for confirming my identifications of the other *Cryptolestes* species and to Mr. B. J. Southgate also of Pest Infestation Laboratory, Slough, for confirming the Bruchidae determinations. Mr. R. D. Pope of the Commonwealth Institute of Entomology made the determinations of *Euxestoxenus, Monotoma, Egadroma* and *Platydema* and confirmed my identifications of *Litargus* and *Silvanus*. The records of *Lyctus africanus* and of *Thorictodes heydeni* from Eastern Province are by Mr. D. W. Hall. Mr. J. Bowden, Senior Entomologist, Uganda, and Mr. T. R. Odhiambo kindly read the draft paper.

Permission to publish this paper has been obtained from the Director of Agriculture, Uganda.

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SHARKS OF THE WESTERN INDIAN OCEAN—II

Triaenodon obesus (Rüppell)

By J. F. G. Wheeler, East African Marine Fisheries Research Organization, Zanzibar

(Received for publication on 13th August, 1959)

Triaenodon obesus was first described by Rüppell in 1835 (as *Carcharias obesus*) from specimens up to 3½ ft. in length (1,070 mm.) that he collected at Djetta on the Red Sea. It has since been recorded at a number of localities in the tropical Indian and Pacific Oceans, those of former including the Seychelles (Playfair, 1867), Madagascar (Sauvage, 1891), India (Day, 1889) and the Chagos Archipelago (Wheeler and Ommanney, 1953), but, curiously enough, it has not been observed until recently in Zanzibar or among the fishes of East Africa (Playfair and Gunther, 1866, Copley, 1952), nor does it range to the south far enough to be included among the fishes of southern Africa (Barnard, 1927, Smith, 1949).

Day (1878) described a second species, *obtusus*, from a young male 19 inches long (483 mm.) collected at Kurrachee (Karachi). In this specimen the first dorsal was much further forward than in *obesus*, so far indeed that the pectoral overlapped it as far as its mid-point; also the second dorsal was considerably smaller than that shown in Rüppell's figure or in the actual fins of preserved specimens in the British Museum. This species has not been found again as far as I know, but from the evidence of my specimens it does not appear to be a growth stage of *T. obesus*.

MATERIAL

The description that follows is based on a full series of measurements and notes taken from three immature females with a profile outline of one of them and a drawing of the underside of its head which was preserved and has since yielded the jaws and teeth. I have some measurements and a painting of a mature male caught at Peros Banhos in the Chagos Archipelago: also another record with a few measurements of a pregnant female caught at the same time and place. All the measurements, calculated as percentages of the total lengths, are given in the table appended. Those of the male from the Chagos have been taken from the painting, the outline of which was reduced from the profile made from the shark itself. The method of outlining and reduction was described on page 43 in the Report on the Mauritius-Seychelles Fisheries Survey, 1948-49 (Wheeler and Ommanney, 1953).

Details of the material examined are as follows:—

(1) Female, 680 mm. long, 2¼ lb., caught on a handline from 5-8 fathoms, Vulture Bank, Mafia Channel (north) on 4th March, 1955.

(2) Female, 830 mm. long, 5 lb., caught in a trammel net on Tutia Reef, South Mafia, on 20th June, 1956.

(3) Female, 837 mm. long, 3 lb., caught on a handline at Jewe Reef, Kilwa Main Pass, on 30th October, 1958.

(4) Male, mature, 1,100 mm., 12 lb., caught on a handline off Yeye Island in the Lagoon of Peros Banhos, Chagos Archipelago on 17th October, 1948.

(5) Female, mature, 1,170 mm., 16 lb., caught on a handline at same place and time as No. 4 above. Pregnant with two foetuses, 47.5 mm. and 50 mm., sex undetermined.

DESCRIPTION

The Chagos specimens were black-grey on the back of the body, darker on the head and on all the fins, both paired and unpaired. Low on the flanks the colour faded to white beneath. The first dorsal and the upper lobe of the caudal were abruptly tipped with white. The Tanganyika females varied in colour from reddish-brown to mauve-brown on the body, darker again on the head and fins, and again white beneath. In one specimen (680 mm.) there were abrupt white tips to D I, D II and both dorsal and ventral lobes of the caudal. In another (837 mm.) D I was white at the tip but not D II, the dorsal lobe of the caudal was white-tipped but not the ventral. In all the underside of the pectorals was dark at the tip and trailing edge fading into white towards the insertion.

The form is very slim and the head is flat, thin and nearly hemi-spherical in outline from above. Nictitating membranes are present but there are no spiracles, no ridge between first and second dorsals, no evident lateral line, no ventral caudal pit, and when lifted the body seems very limp. This lack of rigidity is a noticeable feature, as is the unusual smoothness of the skin, and, of course, the size of the second dorsal and anal relative to the size of the animal (Fig. 1A). The gill slits are large. In the 1,100 mm. male the second, third and fourth were about equal in length at 35 mm., i.e. 3.2 per cent of the total length (3.1 per cent average length in the immature females). In the pregnant female of 1,170 mm. the third gill slit measured 40 mm.—3.4 per cent total length. Labial furrows are confined to the angles of the mouth (Fig. 1B).

The dentition in the specimen I examined (680 mm.) was $\frac{23\text{-}1\text{-}25}{22\text{-}1\text{-}22}$ (Fig. 1 C). The teeth are in the main tricuspid with the centre cusps considerably longer than the side ones and they are similar in both jaws. In a few teeth there is a second anterior cusp. In my specimen the 8th, 9th and 10th teeth in the upper jaw on the left and the 7th to the 10th on the right were quadricuspid and so were the 7th to the 12th on the left and the 7th to the 14th on the right in the lower jaw. Further back this cusp merges into a knob at the base of the central cusp.

The scales are loosely spaced, irregular in size, faintly keeled with as many as eight keels, and gently incurved (Fig. 1D). The surface of each scale appears glazed like porcelain and their free ends are without projections, hence the smoothness of the skin.

The percentage measurements indicate that the head as far as the gill slits tends to become shorter relative to the increasing length of the growing shark. That growth concerns the body rather than the head latterly is shown by the relative increases in the distance of D II from D I and from the snout to the origin of the anal. According to Klunzinger (1871) this species may attain 1½ m. I believe this to be the extreme limit of growth.

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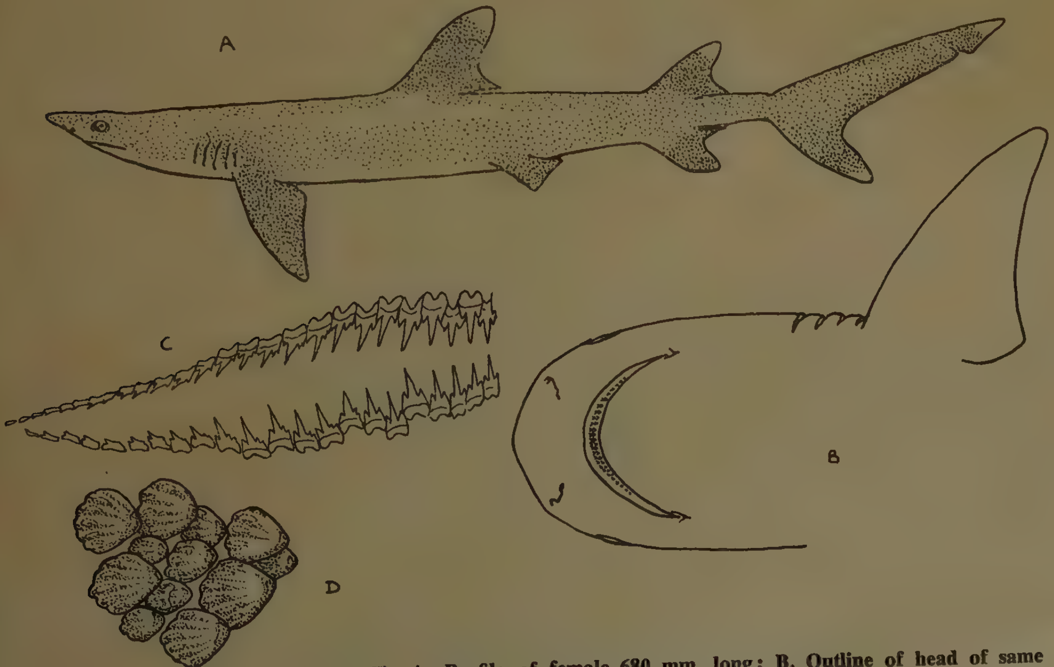

Fig. 1.—*Triaenodon obesus* **(Rüppell). A. Profile of female 680 mm. long; B. Outline of head of same from below; C. Teeth of upper and lower jaws of same; D. Scales of same.**

Triaenodon obesus (Rüppell)

	F. 8–3–55	F. 23–6–56	F. 9–10–58	Av. per cent	F. 17–10–48	M. 17–10–48
Total length	680	830	837		1,170	1,100
Snout to line joining ant. end nostrils	2·1	1·3	1·8	1·7		1·1
Snout to line joining post. end nostrils	2·9	2·4	2·3	2·5		1·8
Snout to point of lower jaw	4·4	3·6	3·2	3·7		2·4
Snout to line joining angles of jaw	9·6	8·7	8·6	9·0		6·6
Snout to line joining 1st gill slits	15·4	14·5	14·9	14·9		13·7
Snout to line joining 5th gill slits	20·6	18·8	18·8	19·4		19·2
Snout to axilla of pectoral	24·1	21·7	23·3	23·0		
Snout to origin D I	34·6	35·0	34·6	34·7		35·8
Base of D I	7·4	7·2	8·6	7·7		13·2
End of D I	4·1	4·6	4·5	4·4		
Height of D I	8·1	8·4	9·0	8·5	8·5	6·6
Origin of D I to origin D II	24·3	27·7	28·1	26·7		28·9
Base of D II	5·9	5·4	6·2	5·8		9·2
End of D II	3·2	3·4	3·9	3·5		
Height of D II	5·1	5·4	5·7	5·4	5·1	4·5
Origin D II to base of caudal	14·7	15·0	13·6	14·4		13·7
Dorsal edge of caudal (straight)	25·7	25·3	25·1	25·4		22·4
Base caudal (dorsal) to notch	8·1	8·2	8·6	8·3		
Base ventral lobe to notch	8·5	7·8	7·8	8·0		
Ventral base to tip of ventral lobe	12·9	12·7	13·1	12·9		11·1
Snout to insertion of pelvics	45·6	47·0	47·2	46·6		46·8
Ant. edge pelvics	7·4	7·3	7·2	7·3		
Post. edge pelvics (median)	2·9	3·6	3·6	3·4		
Post. free edge pelvics	5·9	6·0	6·6	6·2		
Snout to origin A	58·8	62·7	60·9	60·8		64·2
Base of A	5·3	5·4	6·0	5·6		4·2
End of A	2·6	3·1	3·7	3·1		3·7
Height of A	4·4	4·8	5·4	4·9		4·2
Origin A to base of caudal (ventral)	13·9	13·6	14·3	13·9		
Ant. edge pectoral	13·7	13·9	14·3	14·0		12·9
Greatest width of pectoral	8·2	8·4	8·4	8·3		6·6
Depth body at D I	8·1	9·0	—	8·5		11·3
Length 3rd or longest gill slit	3·5	2·7	3·1	3·1	3·4	3·2
Largest diameter eye	2·2	1·9	1·0	1·7		
Distance between ant. ends of nostrils	8·5	6·6	6·9	7·3		
Width head at eyes	10·6	10·8	10·8	10·7		
Width head at 1st gill slit	11·4	13·0	13·1	12·5		
Snout to centre of eye	6·2	5·1	5·3	5·5		
Distance between post. ends of nostrils	4·5	4·7	5·0	4·7		
Distance between angles of jaw	9·4	8·4	8·7	8·8		
Width of head at gape	11·4	12·0	12·2	11·9		
Origin of pectoral to origin of A	26·5(?)	44·0	43·0			
Origin of pelvic to origin of A	14·7	15·1	14·7	14·8		
Length of claspers	—	—	—	—	—	9·2
Presence or absence of ridge		0	0			

REVIEWS

Flora of Tropical East Africa, published by the Crown Agents for Oversea Governments and Administrations, 4 Millbank, London, S.W.1.

Leguminosae subfamily Mimosoideae by J. P. M. Brenan, May, 1959, pp. 73, 23 figs., Index, price 12*s*.

The first part, Mimosoideae, of the large and important family Leguminosae has now been published. Nineteen genera are represented in East Africa amongst which are the Acacias and the Albizias.

The genus *Acacia* is one of the most important and the dominant constituent of the vegetation of the drier parts of Eastern Africa and the large number of 67 species are described and represented by six figures in which most of them are represented by drawings of their pods, an important specific character.

Albizia is represented by 21 species, many of these are flat-crowned trees found in the higher rainfall regions of Eastern Africa although *A. anthelmintica* Brongn grows in dry country.

Economically important for its timber, is what used to be known as *Piptadenia buchananii* Baker. As it is now considered that the genus *Piptadenia* is restricted to the New World this species has to be called *Newtonia buchananii* (Baker) Gilb. and Bout., it is a 120 ft. tall tree found in upland and lowland rain forest at an altitude between about 2,000 and 7,000 ft. and it occurs in Uganda, Kenya and Tanganyika thence through Nyasaland, Portuguese East Africa, Angola, the Rhodesias to the Belgian Congo. The genus *Newtonia* contains two other species, *N. paucijuga* (Harms) Brenan, found in lowland rain forest and riverine forest and restricted to the coastal regions of Kenya and Tanganyika and *N. hildebrandtii* (Vatke) Torre found in riverine forests, dry areas with a high water table and in bushland, it ranges from the Northern Frontier Province of Kenya through Tanganyika then Portuguese East Africa, Southern Rhodesia and Zululand. The genus is characteristic in having long strap-shaped leathery pods with very flat shiny dark-brown seeds which are margined with a narrow papery wing.

The author, Mr. Brenan, not only deals with the indigenous species in this part of the flora but describes some of the more commonly cultivated species as well. In *Acacia,* "Mimosa" of the florists' shops of the U.K., he has a key to the 20 exotic species grown in East Africa including *A. mearnsii* De Wild., the wattle of commerce. The same applies to *Albizia* as several exotic species are used as shade trees.

Keys to the 19 genera are provided as well as keys to the species; each genus is described, as is each species. Under a species references to the literature are given and its distribution throughout East Africa with extensions of geographical range when a species occurs elsewhere. A limited number of collectors specimens are also quoted under each area where they are found, an advantage to a Herbarium worker making an intensive study of the East African flora as it is a help in elucidating a species, particularly when an author's interpretation of a species may be obscure.

Most of the genera are illustrated by full page line drawings showing a branchlet with flowers and where possible fruits and seeds including analytical drawings of parts of an individual flower as well as other important characteristics. With these illustrations, which are a credit to the various artists who drew them, most people with little botanical knowledge should be able to recognize a genus in the Mimosaceae which he is trying to name. The illustrations of the pods of *Acacia* should be particularly helpful along with the two keys to the species as two are provided, one based mainly on floral and vegetative characters, the other on pod and vegetative characteristics.

Mr. Brenan is to be congratulated on the accomplishment of a very exacting piece of work during which he had to examine many types as well as hundreds of specimens. A task by no means easy as so many of the type specimens described by German botanists, particularly those named by Dr. Harms are no longer in existence.

The Mimosoideae are some of the most important constituents of the woody vegetation of East Africa and for all those who live and work in the area and wish to be able to identify the plants by which they are surrounded this part of the Flora of Tropical East Africa is essential if they wish to know the names of the Acacias and Albizias, etc., which they will see every day even on the shortest of safaris. The price is cheap considering the vast amount of painstaking work entailed before it reached the printers.

P.J.G.

RESEDACEAE by J. Elffers and P. Taylor, November, 1958, pp. 6, 2 figs., Index, price 1*s.* 6*d.*

MELIANTHACEAE by B. Verdcourt, November, 1958, pp. 7, 1 fig., Index, price 1*s.* 6*d.*

DROSERACEAE by J. R. Laundon, May, 1959, pp. 6, 1 fig., Index, price 1*s.* 6*d.*

REVIEWS IN BRIEF

BIBLIOGRAPHY OF FOOD AND AGRICULTURE MARKETING, Food and Agriculture Organization of the United Nations, Rome, 1958.

This lists the technical papers concerned with the marketing, transport and storage of food. It gives brief summaries of each.

SOIL AND LAND-USE SURVEYS, by the Regional Research Centre of the British Caribbean. Obtainable from the Imperial College of Tropical Agriculture, Trinidad, B.W.I.

4. Jamaica, Parish of St. Andrew, by K. C. Vernon under the direction of T. A. Jones, 28 pp. and map. Price 12*s.* 6*d.*
5. British Guiana (Mahdia Valley, Bartica Triangle, Kamarang and Kukui Valleys and part of the upper Mazaruni Valley), by J. Stark, H. Hill, G. K. Rutherford, J. Spector and T. A. Jones, 34 pp. and map. Price 14*s.*

As with the previous surveys in this series, these reports summarize the climate, geology, ecology and agricultural practices of these regions. They include descriptions of the soil genesis and profile characteristics, soil classification, land use, physical properties and, in the case of British Guiana, minor and trace element status of the soils.

BIBLIOGRAPHY ON LAND TENURE, 1959, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome. Price 12*s.* 6*d.*

This is the first supplement to the "Bibliography on Land Tenure" which was published by F.A.O. in 1955. The presentation follows the same form.

F.A.O. MARKETING GUIDES, 1 and 2, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome, 1958. Prices (1) 12*s.* 6*d.*, (2) 10*s.*

These are the first two in a new series of F.A.O. publications designed to meet the general demand for information on methods of improving the handling of agricultural products between the producer and consumer, of avoiding wastage and reducing costs.

These marketing guides present in a convenient form experience and recommendations likely to be useful in practical marketing improvement programmes. Each is prepared by marketing experts specifically to meet the needs of the less developed countries. It is intended that these guides should be of continuing service to operators of marketing enterprises, to group marketing organizations and to administrators of government policy.

Marketing Guide No. 1, "Marketing Problems and Improvement Programs", introduces the series with a critical review of the main difficulties experienced in food and agricultural marketing in the less developed countries and ways by which they are being overcome.

Marketing Guide No. 2 deals with fresh fruit and vegetables.

TABULATED INFORMATION ON TROPICAL AND SUB-TROPICAL GRAIN LEGUMES, Food and Agriculture Organization of the United Nations, Rome, 1959. Price 17*s.* 6*d.*

This publication brings together for the first time much information about the botanical characteristics, agronomy and utilization of some 360 tropical and sub-tropical species and varieties of grain legumes. It consists mainly of information sheets, each of which contains a description of individual species or varieties arranged in alphabetical sequence according to a Key of Tabulated Information.

While it is mainly of interest to specialists, it is also a useful source of information to anyone concerned with grain legumes. It should be in the library of every agricultural department in the tropics or sub-tropics.

BIOGEOGRAPHY AND ECOLOGY IN AUSTRALIA, edited by A. Keast, R. L. Crocker and C. S. Christian, published by Dr. W. Junk, Den Haag, 1959, pp. 640 + 56 figs. Price 65 Dutch guilders.

This book is the eighth in the series of Monographiae Biologicae. It deals with the distribution of the flora and fauna of Australia and pays particular attention to the influence of environment. Each chapter of the 37 is written by a specialist and all are extremely readable. They range from such subjects as grasshoppers and termites to species distribution of eucalyptus and ecological research in semi-arid regions. Indeed, it is difficult to indicate how wide a range is covered. Unfortunately, it is somewhat expensive for private buying. However, it should be in every library, scientific or otherwise, for it is likely to prove a valuable reference book for many years.

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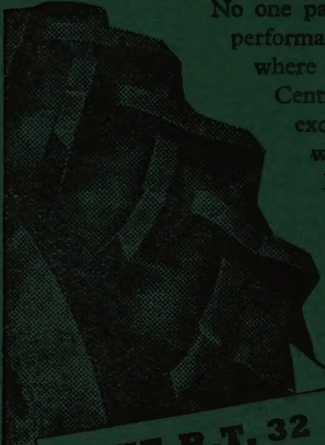
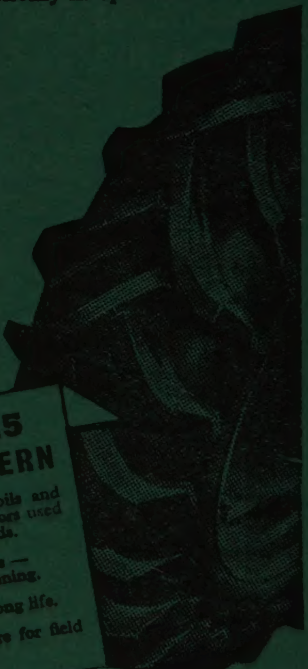
No one pattern tractor tyre will give the best performance under *all* conditions. In countries where the soils are heavy, Dunlop 'Open'-Centre tyres are popular because of their exceptional grip, but for light soils and where long tyre life is important Dunlop 'Closed' - Centre tyres are recommended. Whatever your conditions of use you can be certain that Dunlop tractor tyres will give you maximum satisfaction with economy in operation.



THE R.T. 32
'OPEN' PATTERN

1 Outstanding gripping power, especially on heavy clay soils.
2 A special feature of the design increases grip on the land wheel, i.e., the tyre not in the furrow.
3 Extra rigidity in the tread bars lessens distortion and ensures firm grip under heavy loads.
4 A perfected design prevents soil packing into the tread pattern.



THE R.T. 25
'CLOSED' PATTERN

1 Closed grip on light soils and long tread life on tractors used for haulage on hard roads.
2 Sharp angled tread bars — unequalled for self cleaning.
3 Extra deep tread for long life.
4 A double purpose tyre for field or road work.

TRADE MARK

DUNLOP
TRACTOR TYRES

THE GREATEST GRIP ON EARTH!

8ABH/51

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PRINTED BY THE GOVERNMENT PRINTER, NAIROBI